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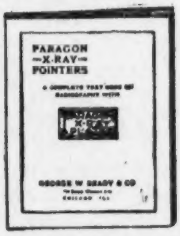

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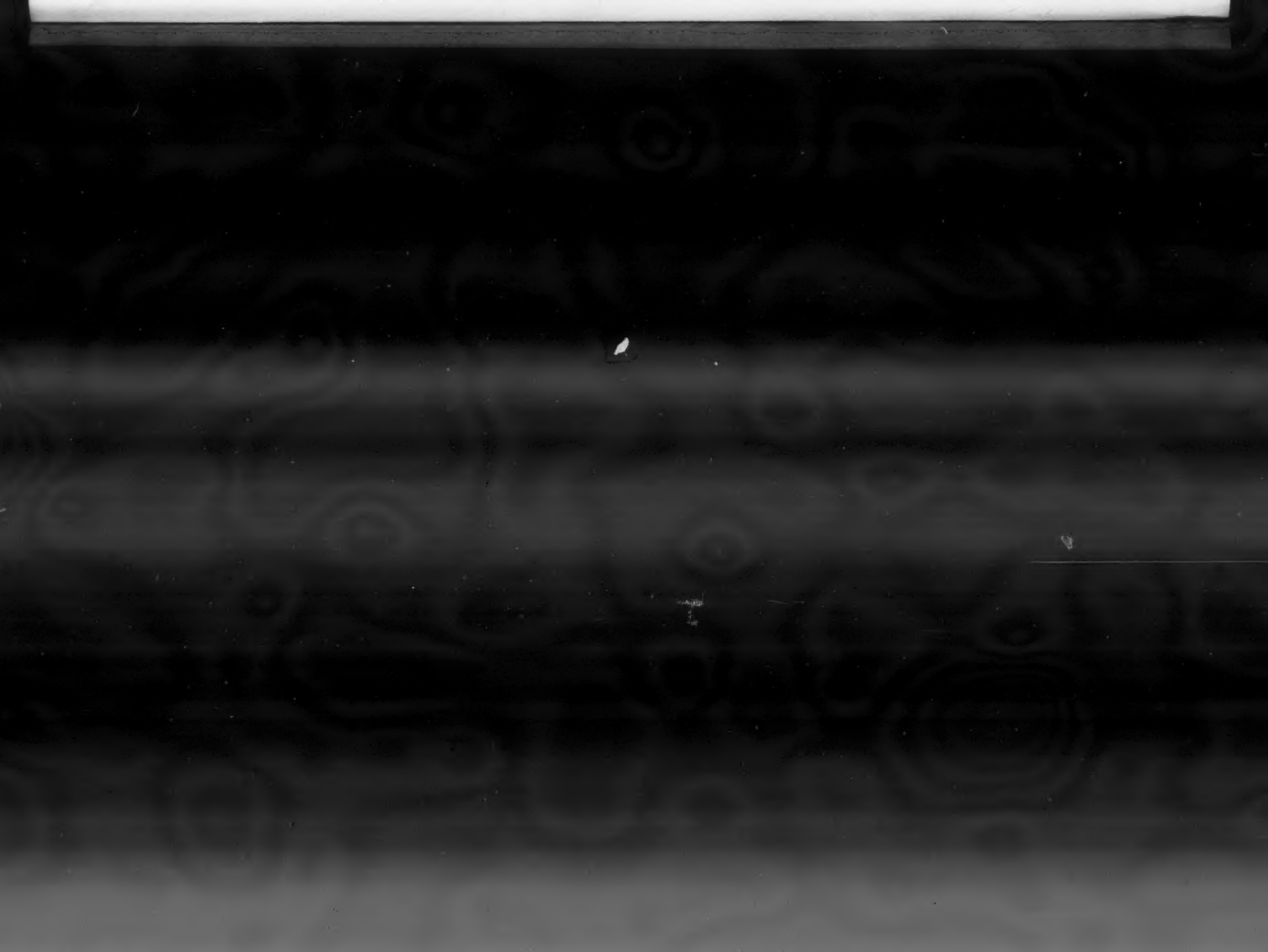

SURGERY, GYNECOLOGY AND OBSTETRICS

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FASCIA TRANSPLANTATION INTO VISCERAL DEFECTS

AN EXPERIMENTAL AND CLINICAL STUDY[1]

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INTRODUCTION

AFTER the principles of free fascia transplantation had been established, chiefly through the pioneer work of Kirschner, fascia grafts were soon employed for a great variety of purposes. Many conditions offered possibilities for correction by fascia transplants, and a considerable number of cases of successful clinical and experimental transferences into *aseptic* fields have accumulated in the literature. These studies have not definitely settled the ultimate fate of transplanted fascia, but they have demonstrated clearly that, for practical purposes, fascia is a remarkably satisfactory tissue for transplantation.

A field absolutely free from the likelihood of infection and rigid asepsis at operation, have always been considered absolutely essential for any successful transplantation. It was, therefore, expected that attempts to transplant fascia into *non-aseptic* areas would fail. A few successes and about an equal number of failures, both clinical and experimental, have been reported. Thus, fascia transplantation into unaseptic fields was considered very unreliable, and was practically discarded. From a survey of the subject, however, I believed that the question had not been investigated sufficiently. Above all, it appeared of great interest, from the practical as well as the experimental side, definitely to determine if fascia can be safely and satisfactorily employed for bridging defects in hollow viscera. This aspect of the subject was especially considered in the work on fascia transplantation, carried out in the past two and one-half years, and will be particularly dwelt upon. Its practical significance will appear in the descriptions of experimental groups, and in the presentation of two cases, one of tracheal and one of urethral defect, to be given at the close of the paper.

Most of the experiments to be reported are devoted to the types of fascia transplantation that have hitherto failed or have not been attempted. For the purpose of arriving at a well-balanced conclusion, the failures as well as the successes will be emphasized.

THE ADVANTAGES OF FASCIA AS A TISSUE FOR TRANSPLANTATION

The free transplantation of fascia is only a small part of the whole subject of tissue transplantation. There are many conditions for which fascia transplants, in contrast to transplants of other tissues, would be undesirable or could not be employed. When Kirschner first reported his work, he believed the procedure to be of limited practical application and value. He was led to employ fascia as a substitute for tendon defects be-

[1] Awarded the Biennial Prize for 1916, of the Alumni Association of the Columbia University, College of Physicians and Surgeons.

cause the quantity of tendon material that could be grafted autoplastically was very limited, and because fascial tissues are so remarkably similar, in anatomic structure, to tendon. Since Kirschner's publication, the practical uses that have been made of fascia transplants have multiplied rapidly. It is, therefore, pertinent to inquire into the advantages of transplants of fascia over transplants of other tissues for conditions in which, up to the present time, the latter have been employed or suggested. In this inquiry autotransplants alone will be considered.[1]

Numerous experimenters (Kirschner, Davis, von Saar, Valentin, and others) have demonstrated that fascia transplants usually heal in place with practically no changes in the fascia or in the adjoining tissues. This holds true not only when the parts are at absolute rest, but also when the transplant is under tension, or is altered in shape and position with the changes in the organ to which it has been transferred. These experimental observations have been supported by a number of corresponding ones in the human being. Indeed, the tendency of transplanted fascia to heal in place must be extraordinarily great to account for results encountered not only in simple cases, but also when the conditions were thought very unfavorable for the success of any transplant — poor blood supply in the region of the graft, nourishment possible to only one surface, etc. An analysis of the reported cases shows that there have never been any undesirable manifestations as a result of transplanting fascia into aseptic fields.

Without entering into the vexed question of the ultimate fate of transplanted tissues, one may say that, as far as fascia is concerned, it has not been definitely settled. The reason for this lies in the inadequately elapsed time of observation after fascia transplantations. Within the limited period, however, most experimenters find that few, if any, significant changes are seen in the characteristic structure and staining qualities of transplanted fasciæ. Some have noted œdema of the transplant soon after transference. Its viability does not appear to have been affected as a result, except when, very rarely, the primary swelling was too great (von Saar). Concerning the fate of transplanted fascia in the human being, most of the examinations have been made relatively soon after operation, and the fact that transplants have been found viable is no evidence of their final condition. In this connection the more prolonged observation in a case reported by Denk is of interest. He examined a sheet of fascia 11 months after its implantation into a dural defect. The transplant was transformed largely into dense fibrous tissue, apparently as the result of its gradual disintegration with simultaneous connective-tissue replacement. It is therefore evident that the fate of transplanted fascia is not known, and that the probabilities are in favor of its ultimate death. From the practical side, however, the question does not appear to be of any great importance. There is no reason to believe that the sheet or strip of good firm tissue that may finally form, functioning as the original transplant, is less serviceable than living fascia.

In comparing autotransplantation of fascia with that of other tissues — fat, muscle, skin, peritoneum, periosteum, etc. — its practical advantages are at once evident. Besides its great tendency to heal in place, fascia requires minimal blood supply for its nourishment. It is always very readily obtainable and, a factor of great importance, in almost unlimited quantities. Fascia has great tensile strength and, at the same time, shows very little tendency to stretch or to shrink, under ordinary circumstances. Lastly, it is easily adapted to the surfaces of any organ. None of the other tissues suggested or used where fascia is applicable, has all these characteristics. Those approaching nearest are peritoneum (when resistance to tension is not required) and periosteum (when resistance is required). Kolaczek urged the use of transplants of peritoneum for a number of conditions because it is lined by smooth mesothelium. The perishability of mesothelial cells is very well known; in fact Kolaczek could not demonstrate that they remained

[1] The arguments here advanced represent, in the main, the views held by Kirchner, Kleinschmidt, and others. In some respects they have been modified to conform with opinions I have formed from personal experiences and from analysis of many reported studies.

alive when the peritoneum was transplanted. Furthermore, the applicability of peritoneal grafts is very limited and the sacrifice of large sections of peritoneum is certainly not harmless. Long, narrow strips of periosteum from the subcutaneous surface of the tibia are almost as readily obtainable as fascia. If, however, long wide sheets are required, the deeper surfaces of the tibia must be exposed. This is objectionable because it requires considerable dissection. Should an infection of the wound occur, the complication is far more disagreeable than an infection of the subcutaneous wound after the removal of fascia. Finally, periosteum is not as plastic as fascia, does not hold sutures as well, and probably retains its structure for much shorter periods.

It is hardly necessary to direct attention to the importance inherent in the fact that the transplantation of fascia can invariably be autoplastic, for the many advantages of autoplastic over other types of transplantation — greatest probability of the transplant healing in place, guarantee against transmission of infection, etc.— are now generally agreed upon.

The Clinical and Experimental Uses of Fascia Transplants

To obviate the impression that fascia is universally applicable as a transplantable material, attention was called to the fact that there are many purposes for which it is undesirable or inapplicable. The clinical and experimental uses to which fascia transplants have been subjected, or for which they have been suggested, will now be considered.

I. Fascia transplants into aseptic fields

A critical analysis of all the results will not be attempted. This has been made by Kirschner, Kleinschmidt, and others, and the advantages of transplantation of fascia over ordinary surgical measures for many affections have been pointed out. I shall take up certain applications in detail in the sections devoted to additional work in such fields. However, a brief survey of all reported applications is desirable, as an index of what has already been accomplished. Fascia has been employed either in the form of sheets or of strips.

Sheets of fascia have been used (1) to fill gaps at operations for hernia, especially umbilical, postoperative, and recurrent. Very many satisfactory results have been obtained, especially when the usual procedures might have been expected to fail because of very large defects, poorly nourished cicatricial tissues, etc. Up to the present time, no failures have been recorded after the use of fascia. (2) For defects of the cranial dura. The procedure has been found remarkably satisfactory in more than 80 reported cases, and has been demonstrated to be free from danger. The fascia heals in place without reaction and almost invariably makes a water-tight closure. (3) For thoracic defects. The few recorded results have been excellent. The details will later be considered. (4) For wounds of solid organs. Large bleeding areas in the liver have been satisfactorily covered by fascia in several instances. It has been suggested for wounds of the spleen and kidney; in the latter case the possibility of extravasation of urine would militate against its use. Fascia transplantations into wounds of the lungs as well as of the liver will be taken up later. (5) For isolation of nerves with the object of preventing fresh adhesions after nerves have been freed from beds of scar tissue. It has been shown, however, that adhesions between nerve and transplant may occur. (6) For reinforcement of blood-vessel sutures and for occlusion of aneurisms. Experiments have demonstrated that sheets of fascia are strong enough to maintain stenosis of large arteries. Clinical experiences have not as yet been reported. (7) For defects of the diaphragm. Some experimental successes and failures have been reported. The question will be discussed later. (8) For interposition in ankylosed joints and for replacement of joint-capsules. A few enthusiastic clinical reports have appeared, but the advantages of the procedure over those ordinarily employed have not been clearly demonstrated.

Strips of fascia have been used: (1) Most frequently to replace or to reinforce ligaments, tendons, or paralyzed muscles. Only a few

of the many satisfactory clinical applications need be mentioned. Defects of tendons have been replaced; the correction of certain paralytic deformities of the shoulder and foot, of habitual dislocation of the patella and of the shoulder, has been successfully practiced; fixation of the "winged" scapula has been accomplished; ocular ptosis has been corrected, etc. (2) To suspend the movable kidney in its corrected position; to anchor the testicle in the scrotum in operations for cryptorchidism. It has been suggested for ptosed liver and spleen. Very few cases have been described. Not all were successful, and one cannot as yet say that the procedure has been placed upon a sound basis. (3) For suture of fractured patella, with the purpose of eliminating the use of foreign material. For the same reason, as well as for its great strength, sutures made of strips of fascia have been suggested for hernia operations. (4) To occlude the pylorus. Some satisfactory clinical results are reported, the operation having been based upon a number of experimental studies. I have shown elsewhere, however, that the experimental grounds for the operation are unsound. It was found that previous experiments had not covered sufficiently long postoperative periods. The conclusion I arrived at after more prolonged observation was that pyloric occlusion did not occur regularly after ligation with fascia strips, and was almost invariably very brief and incomplete when it did follow.

II. FASCIA TRANSPLANTS INTO AND ABOUT THE HOLLOW VISCERA

The very few efforts that have been made to transplant fascia in these regions are based chiefly upon the studies of Koenig and of Hohmeier. The former, in a series of experiments carried out in 1911, reported that leakage did not occur after fascia reinforcement of weak suture lines in the incised œsophagus, stomach, intestine, and bladder, when leakage might have been ordinarily expected. Koenig applied the method in several operations upon the human being, with results that were not always satisfactory. Nevertheless, on the basis of his experiences, Koenig advocated the use of fascia for such purposes. Hohmeier, in his experiments, went one step further; he attempted to bridge complete defects of the bladder, œsophagus, and trachea, by fascia sheets. His work is the source of statements in the literature to the effect that fascia has been transferred successfully into such defects. The unsatisfactory outcome of Hohmeier's experiments, especially in transplants into vesical defects, will be subsequently indicated. Kostenko and Rubaschew, as well as Joffe, demonstrated in a large series of experiments that it was in most instances essential to preserve the continuity of the mucous membrane of the hollow viscera in transplanting fascia over them. All these studies will be considered in greater detail. I wish to point out here that the only grounds for the rather generally held impression, that the various hollow viscera have been successfully "patched by fascia" experimentally, are the reports of very small tracheal and œsophageal defects that have been treated in this way. There is a single instance of successful fascia transplantation into a defect of a hollow organ in the human being. This is a case of tracheal fistula, reported by Levit, which will be described later. An unsuccessful attempt to bridge a urethral fistula by fascia comprises the only additional effort in this field.

On the other hand, Koenig's results in the *reinforcement of suture lines* in the bladder led to similar successful attempts by other surgeons. These will be sketched very briefly. Schmid reports a vesicovaginal fistula operated upon several times without relief. He closed the opening in the bladder, sutured over it a piece of fascia 2 x 3 centimeters, and approximated the freed flaps of cicatricial vaginal mucous membrane. Smooth healing followed. In several instances, Bumm succeeded in supporting large vaginal prolapses by implanting fascia sheets under the mucous membrane between the pubic bones; his report, however, was made shortly after the operations were performed, and the final results are unknown. Henschen was the first to employ supporting strips of fascia in a case of rectal prolapse; the result was perfect, despite some suppuration in the wound

and partial exposure of the transplant. His method was successfully modified by Juracz and by Brun. From these reports conclusions entirely favorable to the practical use of fascia transplants about the hollow viscera would naturally follow. It should, therefore, be stated that sloughing and necrosis of the transplanted fascia occurred in all the reported cases other than those above mentioned — fascia rings about sacral anus after resection of the rectum (Enderlen, Kirschner), fascia over end-to-end suture after resection of intestine (Koenig), fascia over sutured urethra (von Hacker, Hohmeier, Koenig), and one case in the four fascia transplants reported by Bumm.

III. FASCIA TRANSPLANTS INTO INFECTED FIELDS

Closely related to the question discussed in the preceding section is that of fascia transplantation in the presence of infection. This aspect of the subject has received very scant attention. Yet an analysis of some of the reported experiments indicates that necrosis of fascia transplants need not necessarily occur when the field becomes accidentally infected. In fact, several experimenters (Davis, Kornew, Hirano) noted this; Davis remarked that "the transplanted fascia seems particularly resistant to infection for it retained its structure despite sloughing of the surrounding tissues." There are a few clinical reports of fascia having been deliberately transplanted in the presence of infection. Although no general conclusion can be drawn from this very small group of cases, they are of interest in connection with the work to be reported and will therefore be given in detail.

Kirschner. Radical operation for vesical extrophy. A defect 10 x 12 centimeters of the entire abdominal wall, soiled by urine and fæces, remained. The sole closure of this infected gap was the transplanted fascia. The skin and subcutaneous tissues could not be entirely sutured over the transplant, the latter being exposed over an area 4 x 10 centimeters. Despite these conditions, necrosis of the fascia did not occur and a hernia did not develop. Death from pyelonephritis supervened 44 days after operation. At postmortem examination, the transplanted fascia was firmly healed in place. Microscopically it was found normal in structure and staining characteristics.

Rittershaus. Operation for fæcal fistula, situated in a patch of granulation tissue and complicated by a very large ventral hernia. The fistula was excised, but the infected layers of the abdominal wall could not be approximated. A large sheet of fascia lata was implanted in the defect, its inner surface being in contact with the suture line in the intestine. There was slight discharge from the wound for a few days. It healed firmly, however, and the patient was well, free from infiltration in the scar and from postoperative hernia when seen one and one-half years later.

Riese. Operation for purulent sinus and hernia after appendectomy. There were many adhesions; part of the cæcum had to be resected. The whole field was infected. The peritoneum was sutured under tension. A sheet of fascia lata 10 x 15 centimeters was implanted to replace the defect in the abdominal wall that could not be closed. A small section from the edge of the transplant became necrotic and escaped from the wound; the remainder healed in place. The final result was excellent; a hernia did not develop.

Schmid. Fascia transplanted into a defect at operation for ventral hernia. An abscess developed in the wound, sloughing of subcutaneous tissues and discharge of sutures followed, but necrosis of the transplant did not ensue. The wound healed firmly.

Joffe. Intestinal fistula and hernia following appendicitis. At operation the fistula was closed but the layers of the abdominal wall could not be approximated. A sheet of fascia 4 x 5 centimeters was taken from the anterior rectus sheath and implanted into the defect. Partial necrosis of the transplant followed. Nevertheless, the wound healed solidly and a hernia did not appear.

An analysis of all these experimental and clinical observations leads to the conclusion that the success of fascia transplants over suture lines or in small defects of the hollow viscera, or into a frankly infected field, can always be considered problematical, and in the nature of a fortunate accident. It is, therefore, not surprising to find that writers consider fascia transplantation neither desirable nor indicated under such circumstances. The results I shall have to report are at absolute variance with those hitherto encountered. They urge, I believe, a complete revision of the subject. Despite these experimental results, however, the practical aspect of fascia transplantation into defects of hollow viscera (as well as into ordinary infected fields), remains largely a question of the future. At the present time the following viewpoint, I believe, is justifiable:

It is realized that necrosis of fascia transferred to the fields in question may result in a deep-seated phlegmon or a complicated fistula. Furthermore, a serious complication — perhaps a fatal one — might follow if there occurred sloughing of, or perforation through, a transplant bridging a defect of one of the hollow viscera. *A priori*, therefore, no matter how satisfactory the experiments to be detailed, their application to the human being can be considered only when the usual surgical measures offer no promise of relief. Unfortunately, this state of affairs exists in some of the difficult problems that are encountered, problems too well known to be discussed here. It was in part as a suggestion for their solution that the studies in transplanting fascia into defects of hollow viscera were undertaken.

Technique of Fascia Transplantation into Visceral Defects with Special Reference to the Hollow Organs

No important new principle was employed in the methods of fascia transplantation that I practiced. Defects were made as previous experimenters had made them, the same fasciæ were transplanted, the technique was, in general, the same. The only explanation that can be offered for the satisfactory results obtained in types of experiments found unsuccessful in the hands of others, is to be found in the *details* of the technique employed.

The one significant difference was in the method of fixing the transplant at the defect. All previous experimenters sutured sheets of fascia *over* defects, to the walls of the viscera beyond the cut margins. By this method they believed that the transplant would be best nourished from the cut edge of the organ, and that it would offer the greatest resistance to tension and the least chances for leakage. In my early experiments this method was followed. It was found that leakage readily occurred between the surface of the organ and the adjoining surface of the transplant, and that the resistance to tension was not great. Evidently a method was required that would prevent the cut margin of the organ from rolling back, would give sutures a firmer hold by being passed through *all* the layers of the organ, would invite the overgrowth of the lining mucous membrane of the hollow viscus, and would most readily supply provisional nutrition to the transplant. These requirements were met by suturing fascial sheets *into* visceral defects. The results of the application of this method were remarkably satisfactory, as will be seen in the various groups of experiments to be recorded.

The only additional differences in technique were in the method of suturing and of hæmostasis. Concerning the latter, previous experimenters took pains to clamp and ligate bleeding vessels at the margin of the defect made in the organ. Considerable devitalization was thus unavoidable, exactly where good nutrition was most desirable. By implanting fascia into the defect, bleeding vessels could be readily caught in the fixating sutures, and ligatures were not necessary. It was also to diminish devitalization that these sutures were not placed as close together as others had advised. Evidently as a result of the method of hæmostasis and application of sutures, and, above all, of the method of implanting fascia *into* and not *over* the defect, *the successful outcome of many of the experiments could be anticipated with absolute certainty.*

Some details of technique will now be considered. Good operating-room asepsis is essential, and that it existed is demonstrated by the almost complete absence of wound infections throughout the various experimental groups. Dogs were the only animals used. The day before operation they were bathed and the skin epilated with barium sulphide paste well beyond the fields of the planned incisions. Ether anæsthesia was employed in all cases. After complete anæsthetization, the skin was thoroughly cleansed with soap and water, alcohol, and 1:1000 bichloride solution.

The organ to be operated upon is exposed, drawn out of the wound (when feasible), and isolated by moist packings. Four points in the wall of the organ are marked by silk threads, and the line of excision passes immediately beyond them. The distance between these points is not estimated but is measured (with a sterilized steel tape). Leakage is prevented, in operations on the

stomach and intestine, by suitable clamps; the contents beyond the clamps are sponged away as soon as the viscera are opened. After the desired excision of the walls of these organs has been made, the cut margins usually evert promptly and the defect diminishes in size. This should not influence one to replace it by a smaller sheet of fascia, for pronounced narrowing of the lumen of the intestine, diminished capacity of the bladder, etc., will naturally result. In fact, it should be determined both by measurement and by guide sutures, that the fascia removed for transplantation is slightly larger than the defect made in the organ.

Fascia from the abdominal wall is fairly satisfactory, is conveniently obtained at abdominal operations, and has been used in a small number of the experiments. Compared with fascia lata, however, it has a number of disadvantages, which apply as well to the human being. It is not as strong, as easily obtained, as smooth, or as large in uninterrupted extent; hernial protrusions followed in two instances when large sections were removed. Therefore fascia lata was employed invariably in all the later experiments. The section of fascia removed should conform closely in shape with the defect made in the organ. Great care is to be observed in its removal. The transplant should receive minimal handling. The lines of incision in the fascia lata should be clean-cut. Portions of the deep surface should not be left behind. The transplant is, of course, quite useless if it has been perforated. The lowest and most dorsal part of the fascia lata is strongest and is, therefore, preferable in most instances.[1] After its shining superficial surface is laid bare, two longitudinal incisions, the desired distance apart, are made down to the underlying muscle. The bridge of fascia between them is elevated by gentle blunt dissection. Its removal is completed by joining the ends of the two incisions, either straight across or with a curve corresponding to the margin of the visceral defect to be replaced. Although the superficial as well as the deep surface of the fascia has been successfully used to face the lumen of hollow organs, it is preferable to turn inward the smoother (deep) surface of fascia lata. The fascia may be placed in warm saline solution before transferring it. This makes it somewhat succulent, however, and not so easily handled. The best procedure is, first to prepare the defect and then to implant the fascia directly into it.

Fine silk sutures were employed in all the experiments and were used on very thin half-curved needles, to avoid making large rents in the fascia. Black silk was used in many instances in order to outline clearly the situation of the transplant. The sheet of fascia is fixed into the defect at 4 points by sutures passed through it from within outward, after having been passed through all the layers of the cut edge of the organ. These sutures are left long. Two on one side are drawn upon and a continuous suture made between them. This suture is passed from without inward through the fascia, and in the opposite direction through all the layers at the cut edge of the organ. This method of passing the sutures is not essential, however, for satisfactory results have been obtained with other methods, provided all the layers of the organ and the fascia, as well, were securely grasped. With any method of suturing, the stitches are placed two or three millimeters apart, not so close as to devitalize the tissues, nor so far apart as to permit gaping. The bite taken through the fascia should be slightly larger than that through the viscus, and, as each stitch is pulled taut, the edge of the fascia is gently drawn upon on both sides of the suture to make it overlap slightly. Every third or fourth stitch is tied. The beginning and the end of the continuous sutures are tied to the fixation sutures. The second, third, and fourth continuous sutures complete the ring and make an uninterrupted suture line of very slightly overlapping fascia. It is important that the transplant should fit in place without fold or wrinkle. If the cut edge of the organ gapes between sutures, additional ones are required from the margin of the fascia to points on the surface of the organ some distance from the primary suture line. Very few will be necessary if the size and shape of the transplant

[1] Similarly, in the human being the area of fascia lata above the external surface of the knee-joint (the iliotibial band) is preferable especially when great strength is required.

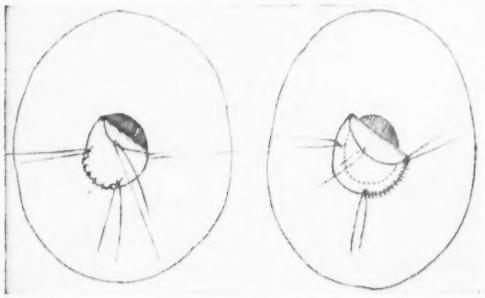

Fig. 1. Diagrams showing the previously employed method of fixing the transplanted fascia over the defect (on the right); and the method of suturing the transplant into the defect, as practiced in the experiments and cases to be described.

are correct and the primary tier of sutures is accurately placed. A complete secondary tier was used in only a very few experiments.

A fluid diet for several days is given after operations on the alimentary tract. This diet is continued for a week or more after operations on the œsophagus. It is then followed by semi-solid nourishment. Neither a permanent catheter nor the administration of drugs was found necessary after operations on the bladder or ureter.

I. FASCIA TRANSPLANTS INTO DEFECTS OF THE BLADDER

These experiments are described first, and will be taken up in greater detail than any of the subsequent ones, because the results obtained have been so striking. The largest number of experiments were performed in this group, yet the outcome of every operation was successful, even when as much as one-half, approximately, of the bladder-wall was replaced by fascia. Apart from the absence of contractility of the filled defect, the functional results were perfect; in fact, resistance to hydrostatic pressure was found to be greatest at and about the newly formed bladder-wall. It is of interest to note that vesical calculi never developed when fascia was employed to replace the defect, but were present around fat transplants used for this purpose. A remarkable feature of these experiments was the development of macroscopic plaques of true bone at the site of transplantation. This began astonishingly soon after operation and reached its height in about two months. Relatively little significance would have been placed upon the formation of osseous tissue were it not for the fact that it developed invariably in all the experiments. Not only bone, but also cartilage and bone-marrow appeared, as well as an ensheathing tissue akin to periosteum. These observations will be detailed. It may be stated here that, from the practical side, the development of bone did not in any way interfere with the functional result. On the contrary, this was probably enhanced by the increased strength of the newly formed bladder-wall. The latter term is used advisedly, for, as will be seen, the results do not depend upon healing by shrinkage of the defect but upon the replacement of the defect by new tissue. Another feature of considerable interest was the extension of smooth muscle-fibers from the margin of the bladder-wall across the site of the defect.

Before detailing the experiments, the previous work done in this field should be reviewed. It has already been said that the statements one finds in the literature are erroneous in referring to appreciable vesical defects having been replaced successfully by fascia transplants. They are based on studies by Hohmeier, and by Kostenko and Rubaschew. Upon analysis of Hohmeier's experimental work, it is found that the results were quite unsatisfactory. Four experiments were performed upon fascia implantation into bladder defects. In one, a "peritonitis from unknown cause," resulted in death a few days after operation. Perforations through the transplants occurred six and nine weeks after operation, in two succeeding experiments. It was only in the fourth that "the fascia appeared firmly healed in place." In this instance death resulted from "distemper" three weeks after operation; the period of observation is evidently not sufficiently long to suggest any definite conclusion, especially in view of the other experiences. Kostenko and Rubaschew[1] found that fascia transplants *occasionally* prevented leakage from

[1] The original publication is unfortunately inaccessible. Abstracts in the *Zentralblatt fuer Chirurgie* and in papers by Kornew and others are the basis for my remarks.

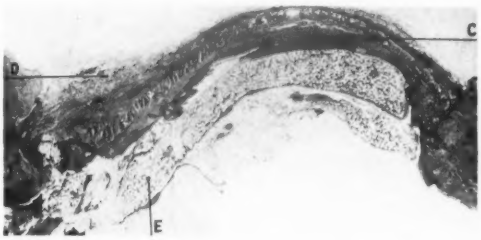

Fig. 2. Pathology No. 3368. Two days after fascia transplant into defect of bladder. *A*, The two layers of fascia attached firmly to bladder-wall at *B*, *B*; *C*, layer of fibrin; *D*, leucocytes on free surface; *E*, adherent omentum.

the bladder when implanted into very small defects (defects less than 2 x 2 centimeters, how much less is not stated). The periods of time after operation at which the observations were made are not given. Healing in these occasional instances depended upon shrinkage of the defect and approximation of the cut edges of the bladder-wall. In general these experimenters agreed with Joffe, who demonstrated that fascia often prevented leakage when implanted over vesical defects after the mucous membrane had been sutured, but that necrosis of the transplant and perforation followed uniformly when the lips of mucous membrane were not approximated.

On the other hand, the experiments of Koenig, Hohmeier, and the others abovementioned, demonstrated that fascia affords a strong barrier against leakage when transplanted over suture lines in the bladder.

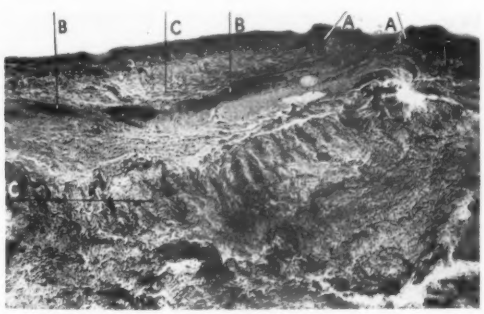

Fig. 4. Pathology No. 3367. Six days after fascia transplant into vesical defect. *A*, Deposits of lime salts on the surface and *B*, *B* in the depths; *C*, *C*, fascia undergoing hyaline degeneration.

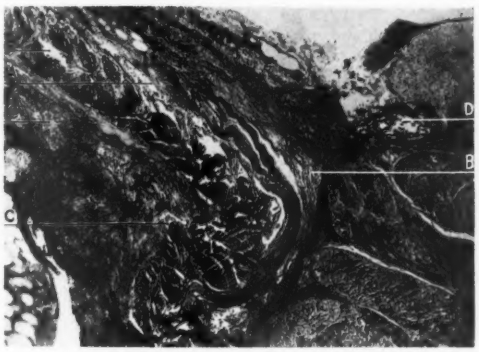

Fig. 3. Pathology No. 3368. Enlargement at *A* in Fig. 2, showing details of repair. *A*, The two layers of fascia undergoing degeneration; *B*, thick layer of fibrin sealing the chink between transplant and bladder-wall; *C*, layer of fibrin, to which the omentum is adherent; *D*, silk suture.

The procedure has been successfully employed in the human being by Koenig and by Kostenko and Rubaschew.

Eighteen experiments were made upon fascia transplantations into vesical defects. There were four fatalities; only one, in which approximately five-eighths of the bladder was replaced by fascia, being due to necrosis of the transplant and perforation. The other three followed infection or rupture of the abdominal wound. The defects made in the bladder varied in size, from 2 x 2 centimeters to about one-half of the bladder-wall.[1] The

[1] In the description of experiments the measured size of the defects will be given rather than their relation to the size of the bladder. The latter varies too greatly with the amount of contained urine to be accurate.

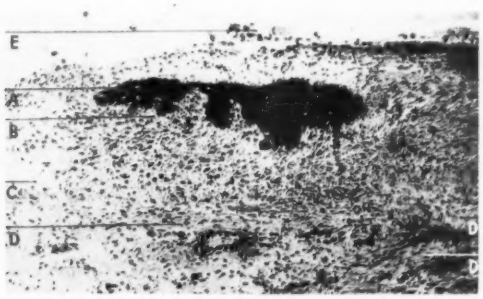

Fig. 5. Pathology No. 3403. Seventeen days after fascia transplant into defect of bladder. *A*, Bone; *B*, osteoid tissue; *C*, loosely woven connective tissue occupying defect; *D*, *D*, *D*, strands of smooth muscle in defect; *E*, *E*, fragments of epithelium on surface.

Fig. 6. Pathology No. 3518. Seven and one-half weeks after fascia transplant into defect of bladder, showing details of the tissues occupying the defect. *A*, layer of epithelium; *B*, *B*, clusters of cartilage-cells in the bone; *C*, *C*, bone-marrow; *D*, row of osteoblasts; *E*, osteoclast; *F*, osteoid tissue; *G*, smooth muscle.

Fig. 7. Pathology No. 3518. Seven and one-half weeks after fascia transplant into defect of bladder, showing details of cartilage in relation to bone.

specimens were examined from two days to five months after operation. The following are a considerable proportion of the experiments, chronologically arranged, and chosen to illustrate various findings.

EXPERIMENT DOG 220. Small male. Opera-

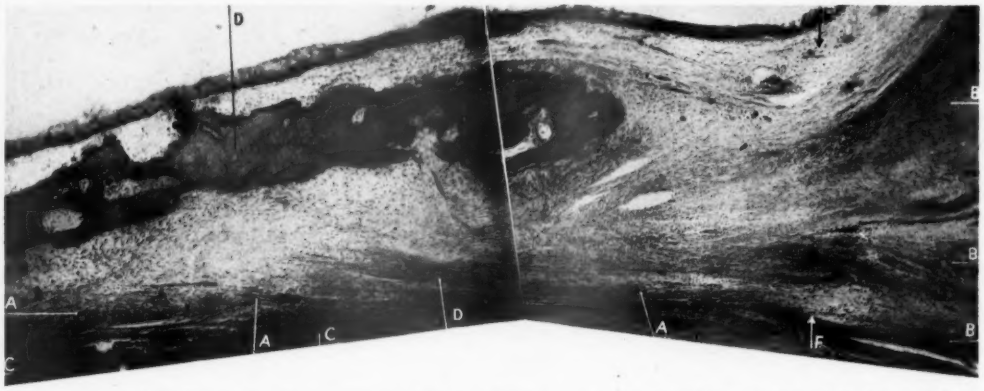

Fig. 8. Pathology No. 3518. Seven and one-half weeks after fascia transplant into defect of bladder, showing general configuration of tissues occupying defect and overgrowth of smooth muscle. Arrows indicate the approximate line of transition from bladder to defect. *A*, *A*, *A*, *A*, Smooth muscle of defect continuous with *B*, *B*, *B*, that of bladder-wall; *C*, *C*, abscess; *D*, cartilage.

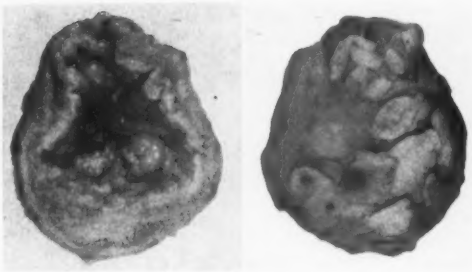

Fig. 9. Pathology No. 3843. Ten weeks after fascia replacement of large quadrilateral defect of bladder. To the right is the moderately distended unopened bladder, the adherent omentum outlining the size and shape of the defect. To the left is the half of the bladder which has been operated on, showing the type of mucous membrane overgrowth.

tion, March 9, 1915. Right hypogastric incision. Bladder moderately full. Isolated from abdominal cavity by moist packings. A circular section from its vertex, 2½ x 2 centimeters removed. Considerable oozing from cut wall, no ligatures applied. Sheet of fascia lata from upper thinner area, of appropriate size and shape, removed and sutured into defect with black silk. When suture was complete the defect, as bridged by fascia, measured 2½ x 1¾ centimeters. Reinforcing sutures not used, the primary tier making snug approximation. Layer suture of the abdominal incision.

Postoperative course. Temperature 102° the day after operation. Wide separation of the wound. Death March 11, two days after operation.

Postmortem examination. Very extensive cellulitis, numerous pockets of pus in all the layers of the abdominal wound. No peritonitis. Anterior surface of bladder with a small part of the transplant adherent to parietal peritoneum in the immediate vicinity of the abdominal-wall infection. The peritoneum is here deeply congested, discolored, shaggy; evidently the infection would soon have invaded the peritoneal cavity.

Congested tongue of omentum firmly adherent at site of fascia transplant. Bladder distended with cloudy urine (containing many pus and red cells); no sign of leakage. Bladder removed and subjected to great hydrostatic pressure; absolutely no leakage. External surface of the transplant not seen (omentum adherent). Viewed from within, the silk sutures outlining transplant showed that defect had not shrunk. Submucous hæmorrhages in bladder-wall near cut margin. Many fine shreds hang from transplant; no concretions about them.

Microscopic examination. Surgical Pathology No. 3368. The fascia transplant is in part broken up and undergoing hyaline degeneration. In some places only a few remnants are seen. The surface facing the lumen (to be termed the "free" surface in all further descriptions) is occupied by numerous

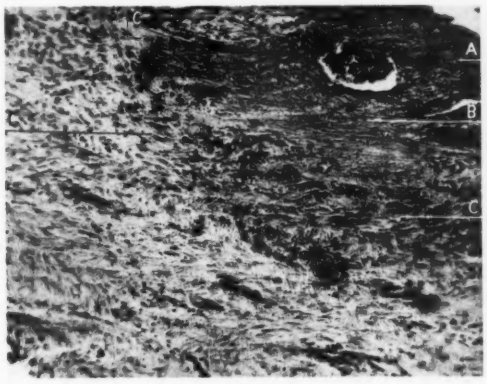

Fig. 10. Pathology No. 3843. Ten weeks after fascia transplant into vesical defect. Showing shading of bone, *A*, into osteoid tissue, *B*, and of this into an adjoining periosteum-like layer of tissue, *C*, *C*, *C*, *C*.

leucocytes, some of which are found among the fascia bundles. The opposite surface of the transplant is covered by a thick layer of fibrin, to which the omentum, rich in blood-vessels, is adherent. Silk sutures at the surface mark the line of demarcation between bladder-wall and transplant. All the layers of the bladder-wall stop sharply at the edge of the defect. They are united to the transplant by a very thick layer of fibrin. There are very many blood-vessels (filled with red blood-cells) near the cut margin of the bladder wall.

EXPERIMENT DOG 210. Large male. Opera-

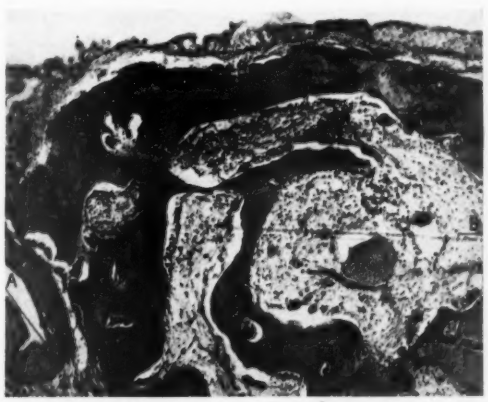

Fig. 11. Pathology No. 3842. Two and one-half months after fascia transplant into defect of bladder. Showing bone extending to the extreme margin of the defect, and very active changes in the osseous tissue. *A*, Site of transition from bladder-wall to tissues of the defect; *B*, large vascular marrow-space in which osteoblasts and osteoclasts are seen.

Fig. 12. Pathology No. 3827. Two and one-half months after fascia transplant into a vesical defect. To the left is the unopened bladder, maximally distended to show the resistance of the tissues filling the defect, situated within the dotted lines. To the right is the interior view, showing the bone plaque in the center.

tion, March 5, 1915. Right hypogastric incision. Bladder extremely distended, oval section removed from anterior aspect measured 3 x 2½ centimeters. Very little bleeding. Lower portion of fascia lata chosen, section of appropriate shape, 2½ x 3¼ centimeters removed, implanted into defect with black silk sutures. Three additional reinforcing stitches. Actual defect then measured 3 x 2 centimeters. Some difficulty in suture of abdominal incision.

Postoperative course. High temperature, infiltration of the wound, no evidence of peritonitis. Death on March 11, six days after operation.

Postmortem examination. Whole lower abdominal wall intensely infiltrated; all the layers widely infected about the line of incision, the musculature in particular being necrotic and liquefied. No peritonitis. Deeply congested slip of omentum adherent to parietal peritoneum at the incision and to the site of operation on the bladder.

Fig. 13. Pathology No. 3827. Two and one-half months after fascia transplant into vesical defect, showing an unusually large marrow-space close to the epithelium.

Bladder tensely distended with clear urine. No evidence of leakage. Both external and internal surfaces of bladder much congested, more so toward the edge of the defect. Here there are several small submucous hæmorrhages. A rather shreddy thin layer of tissue appears to overlay the inner surface of the transplant; exact relation not determined in order to preserve it for microscopic examination.

Microscopic examination. Surgical Pathology No. 3367. The transplant has undergone considerable hyaline degeneration, being scarcely recognizable in several places. Its free surface is covered by a homogenous layer staining faintly blue. Here there are lime deposits, which extend into the depths of the transplant at one place. A layer of young

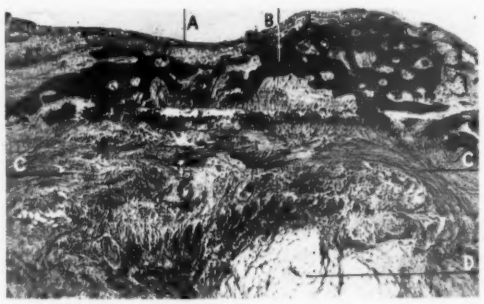

Fig. 14. Pathology No. 2895. Three months after fascia transplant into a defect of the bladder. showing how the plaque of bone reinforced a thin part of the new bladder-wall. *A*, Continuous layer of epithelium, in heaps at the extreme left; *B*, bone; *C*, connective tissue and smooth muscle; *D*, omentum.

Fig. 15. Pathology No. 2895. Three months after fascia transplant into a defect of the bladder, showing the thick vascular layer of connective tissue beyond the bone plaque.

Fig. 16. Pathology No. 3844. Three months after fascia transplant into a bladder defect. To the right is the unopened, empty bladder, the site of the defect being between the dotted lines. To the left is the interior view, showing the bone plaque at the center.

Fig. 17. Pathology No. 3844. Three months after fascia transplant into bladder defect. *A*, Preponderance of osteoclasts; *B*, *B*, *B*, *B*, layer of ensheathing periosteum-like connective tissue.

connective tissue, containing many round cells, occupies the deep surface of the transplant; to this the highly vascular omentum is adherent. The ends of the strip of fascia merge almost insensibly into the adjoining bladder-wall; only the silk sutures definitely mark the boundary.

EXPERIMENT DOG 247. Medium sized, male. Operation, March 19, 1915. Curved hypogastric incision. Bladder almost empty. Defect of antero-superior wall 3 x 2 centimeters. Moderate bleeding from cut edge. Thicker part of fascia lata, 3½ x 2½ centimeters sutured into defect with black silk; a few reinforcing sutures required. Actual defect bridged then measured 3 x 2 centimeters. Layer suture of wound.

Postoperative course. Wound separated soon after operation, some purulent discharge at first, then showed tendency to heal but never closed. Death from large hæmorrhage from wound on April 5, seventeen days after operation.

Postmortem examination. Tissues very pale. Source of hæmorrhage probably the epigastric vessels. Bladder greatly distended with urine, no bulging at site of transplant. Latter outlined by black silk sutures unless they have migrated; no shrinkage, as determined by measurement. Thin layer of bluish omentum adherent to part of transplant. Part of fascia visible is smooth and glistening. Bladder adjoining transplant faintly purple in color. Internal appearance of transplanted area is that of a clean smooth flat healing ulcer. Few old submucous hæmorrhages near edge of defect. Newly formed tissue about transplant is of same thickness as bladder-wall.

Microscopic examination. Surgical Pathology No. 3403. The fascia transplant is not recognizable as such. A loosely woven fluid-like connective tissue occupies its site. In this tissue near (in some sections directly at) the free surface are small masses of bone. The latter is laid down about cells in the typical trabeculated framework, shading off into osteoid tissue by insensible gradations. In some of the slides only deposits of lime are present in situations identical with the bone deposits. The fusion between the bladder-wall and the tissue filling the defect is complete. Beneath the above-described loosely woven layer of tissue, smooth muscle-bundles are seen here and there. They are found to be continuous with the muscle-wall of the bladder at the edge of the defect. The omentum is intimately attached to a layer of connective tissue beyond the muscle-bundles in the defect. Fragments of bladder epithelium are seen here and there on the free surface of the transplant. Presumably they represent epithelial overgrowth from the margin of the defect; however, a continuous layer of epithelium was not found in any of the sections.

EXPERIMENT DOG 242. Rather large male. Operation, March 25, 1914. Incision in right hypogastrium. Bladder distended. Points marked at such distances that removal immediately beyond them would be an excision of about half the bladder-wall. Defect measured 4 x 5 centimeters, extending close to the insertion of the left ureter. Fascia from abdominal wall, slightly larger than this, sutured into defect with white silk. Gap in abdominal fascia partly sutured. Suture of wound.

Postoperative course. Two weeks after operation tympanitic hernial protrusion of abdominal wall at site of fascia excision. This persisted to the end. No urinary symptoms noted. Development of distemper, for which animal was chloroformed April 27, thirty three days after operation.

Postmortem examination. Typical evidences of distemper in examination of the respiratory system.

Fairly broad adhesions of omentum to empty bladder at site of transplant. Vesical serosa deeply congested in region of operation. Measurement between sutures, faintly seen when interior of bladder was inspected, showed slight contraction. Mucous membrane appeared to have grown over the defect down to an area 1½ x 1½ centimeters. This area was occupied by a firm whitish smooth

Fig. 18. Pathology No. 3612. Four months after fascia transplant into a defect of the bladder. Showing the large marrow-spaces and the extreme development of bone-marrow.

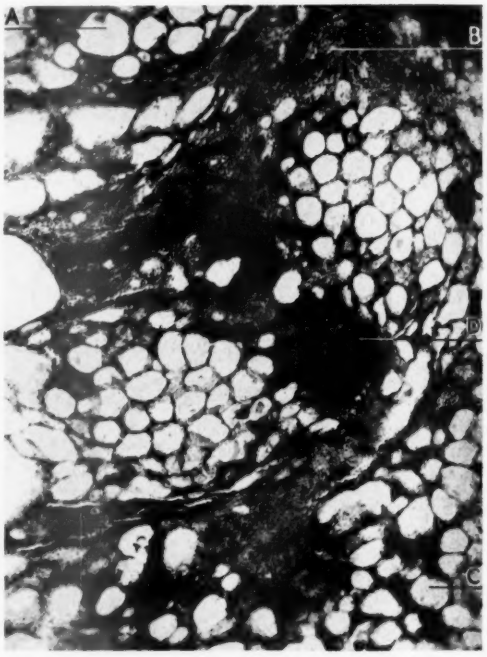

Fig. 19. Pathology No. 3506. Twelve days after transplant of fat into a defect of the bladder. Deposits of lime salts about the fat-cells and in the connective tissue between them, near surface at *A*, *B*, and in depths at *C*, *D*.

plaque, covered by a thin translucent pink membrane (mucosa?). Tested by water distention, no evidence of diminished bladder capacity. Ureters intact.

Microscopic examination. Surgical Pathology No. 2997. A large (macroscopic) plaque of bone occupies the free surface of the defect. It is of irregular shape, especially upon its deeper aspect.

Fig. 20. Pathology No. 3613. Fat transplant into defect of bladder, showing bone formation 2½ months later. Fragmentation of epithelial layer accidental.

Fig. 21. Pathology No. 3613. Two and one-half months after fat transplant into defect of bladder, showing the villous projections.

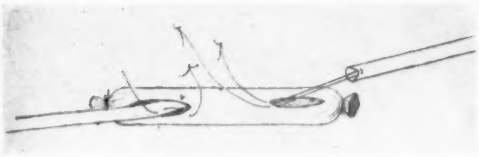

Fig. 22. Diagram illustrating the method of fixing the ends of a resected ureter into a previously made tube of fascia. On the right, the ureter is being drawn through a slit in the tube; on the left, the wall of the ureter is being fixed to the tube at the slit. (The slits are disproportionately large.)

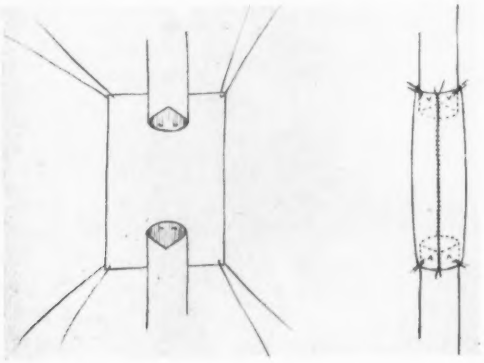

Fig. 23. Diagram to show the method of constructing a fascia tube between the ends of a resected ureter.

The mass of bone is hollowed out into spaces occupied by a loosely woven tissue rich in cells and in blood-vessels, a tissue analogous to young bone-marrow. The free surface of the bone plaque is covered by a layer of epithelium continuous with the bladder epithelium. The deep surface is covered by a thin layer of dense connective tissue analogous to periosteum. Beyond this is a broad zone of dense, poorly staining connective tissue (scar tissue) in which are seen muscle-bundles continuous with those of the bladder-wall at the defect. The tissue occupying the defect merges insensibly with the bladder-wall. Silk sutures identify the approximate position of the defect; it is evident that little, if any, shrinkage has taken place.

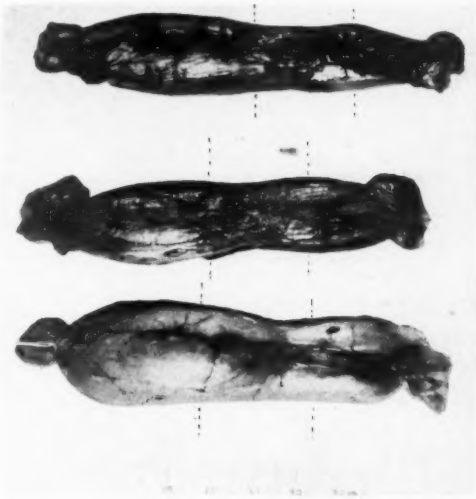

Fig. 24. Exterior views at sites of œsophageal defects replaced by fascia. The tubes are distended with varying amounts of fluid. On top, sixteen days after operation; in the middle, twenty-three days after operation; at bottom, one month after operation.

Experiment Dog 285. Large female. Operation, April 9, 1915. Transverse hypogastric incision through fascia, muscles, and peritoneum, split

Fig. 25. Appearance of interior at sites of œsophageal defects replaced by fascia. *A* (at left), One month after operation; B, twenty-three days after operation; C, sixteen days after operation.

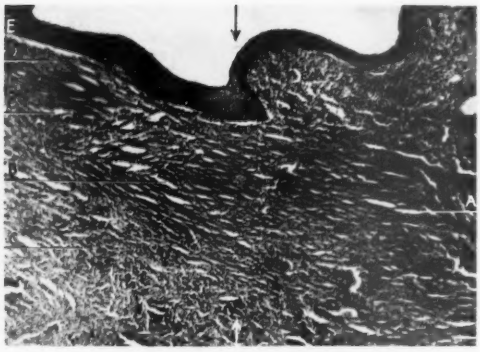

Fig. 26. Pathology No. 3884. Sixteen days after fascia transplant into defect of œsophagus. Arrows indicate line of transition from œsophageal tissues (to the right) to those of the defect (to the left). *A*, Muscle layer of œsophagus extending into defect at *B*; *C*, *C*, degenerating fascia; *D*, organized granulation tissue on the surface of the transplant; *E*, regenerated epithelium raised in folds.

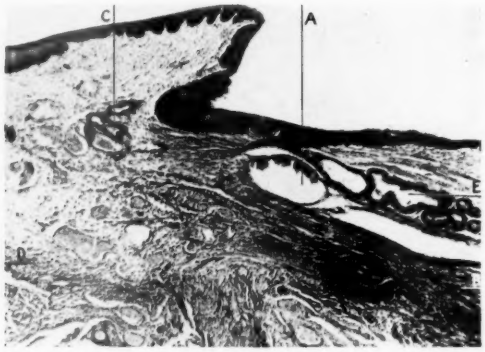

Fig. 27. Pathology No. 3883. Twenty-three days after fascia transplant into œsophageal defect. *A*, Silk suture defining line of transition from œsophageal wall to tissues of defect; *B*, muscle layer of œsophagus extending into defect; *C*, mucous glands found in defect identical with *E*, those of œsophagus; *D*, degenerating fascia.

longitudinally. Bladder moderately distended. Points marked so that excised wall would measure 4½ x 4 centimeters. Fascia lata slightly larger than this sutured into defect with black silk. Beside the primary tier of sutures three additional stitches were placed at points where mucosa pouted slightly between sutures. Small hæmatoma in wall of bladder not touched.

Postoperative course. Uneventful. Slight mange. Animal chloroformed June 2, seven and a half weeks after operation.

Postmortem examination. Bladder fairly full. Ureters intact. Moderate omental adhesion at field of operation. Before opening bladder measurement was made of the solid tissue occupying region of transplant, pale and different from the remainder of the bladder. It was 4½ x 3½ centimeters, indicating little if any shrinkage. This was corroborated by inspection of the interior, when the black silk threads approximately outlined the original size of the defect. A layer of translucent, pinkish, jelly-like tissue, carrying numbers of very fine blood-vessels, is spread over the position of the transplant. Visible through it is a pinkish gray very solid plaque of tissue; touched at one point with a needle, it was found bone-like in consistency, new bladder-wall as thick as the normal.

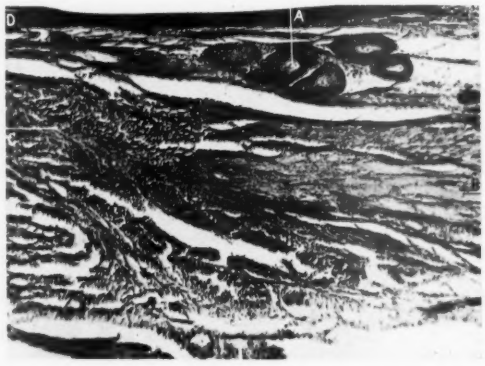

Fig. 28. Pathology No. 3882. One month after fascia transplant into œsophageal defect. *A*, Glands indicating transition line; *B*, musculature of œsophagus extending into the defect at *C*, where it is lost in dense connective tissue; *D*, continuous layer of epithelium.

Microscopic examination. Surgical Pathology No. 3518. A large remarkably well-formed mass of bone occupies most of the free surface of the defect; many typical osteoblasts as well as a number of osteoclasts are seen. Marrow spaces are infrequent and generally small. One end of the bone plaque is fairly smooth and rounded. The opposite end presents two irregular wide-spreading prongs. Filling the space between them and in intimate fusion is a large mass of cartilage (visible macroscopically as a small blue speck). On one side the cartilage-cells are intermingled with the bone-cells; at the other extreme the broad zone of typical cartilage merges gradually into a wide layer of connective tissue akin to perichondrium. In addition to this large deposit of cartilage, there are several small islands of cartilage-cells, scattered throughout the bone plaque. The free surface of the bone plaque is covered completely by epithelium continuous with the normal bladder epithelium. Adjacent to its deep surface is a well-formed layer of connective tissue identical in appearance with periosteum. Beyond this is a thin continuous layer of typical smooth muscle; typical in the color of the stain, in the construction of the cells, in the elon-

gated narrow nuclei. Its continuity with the smooth muscle layer of the bladder-wall can be easily distinguished. Outside the muscle layer there is an abscess, the wall of which brings out the contrast with the smooth muscle. The omentum was adherent to its external surface.

EXPERIMENT DOG 41. Male of average size. Operation, December 1, 1915. Transverse incision. Bladder enormously distended. After puncture a quadrilateral strip from vertex, anterior and posterior walls, 5 x 2¼ centimeters, was removed. Six fixation sutures for the fascia transplant were necessary instead of the usual four (see section on Technique). At two points reinforcing stitches were required over the primary tier. Layer suture of abdominal incision.

Postoperative course. Uneventful. Animal sacrificed with chloroform February 8, ten weeks after operation.

Postmortem examination. Broad omental adhesion at site of operation. Bladder-wall under omentum seen to be more opaque, less pink than the rest of bladder, yet smooth and shining. No bulging here with water distention. Inspected from within, mucous membrane apparently covers tissue filling defect except in one small area into which a few black sutures protrude. At this point the bladder-wall appears thinner. Mucosa at defect more corrugated, thicker(?), pinker than over remainder of bladder. Firm shotty nodules felt underneath.

Microscopic examination. Surgical Pathology No. 3843. The free surface of the tissue filling the defect consists of small papillæ or rugæ covered with an unusually thick layer of epithelium continuous with the bladder epithelium. The stroma of these papillæ is rich in blood-vessels and small round cells. A thick layer of dense connective tissue occupies most of the remainder of the defect. Between it and the villus-like layer is a small area of bone. This shades off gradually into osteoid tissue which in turn merges with a layer of periosteum-like connective tissue. An irregularly distributed layer of smooth muscle bridges the defect, lying for the most part in the deeper surface of the cicatricial tissue.

EXPERIMENT DOG 35. Operation, November 24, 1915. Transverse incision. Quadrilateral defect 4 x 3 centimeters in the anterosuperior part of bladder replaced by fascial sheet 4½ x 3½ centimeters. In this experiment the vessels in the bladder-wall were unusually large and three were ligated a short distance from the edge of the defect. Four reinforcing stitches at necessary points over the primary continuous suture.

Postoperative course. Nothing unusual. Animal chloroformed February 8, 1916, two and a half months after operation.

Postmortem examination. Omentum adherent to bladder over a very firm plaque of tissue occupying site of defect. This tissue approximates closely the size of the original defect, is differentiated from the remainder of bladder-wall by its less pink color, and its border is well outlined by the black silk sutures. Inspection of the interior discloses mucous membrane covering the region of the transplant except at one place where a silk suture hangs free.

Microscopic examination. Surgical Pathology No. 3842. The fairly large plaque of bone that formed near the surface of the defect shows great activity. Many osteoblasts and osteoclasts are seen, the bone mass being laid down in very irregular grotesque forms. Epithelium is continuous over the site of the defect, even where the bone is prolonged into pointed projections. The connective-tissue layer ensheathing the deep surface of the bone plaque is closely analogous to periosteum. The layer of smooth muscle bridging the site of the defect is not as readily distinguishable as in previous specimens, yet can be seen in the dense connective tissue occupying most of the defect beyond the bone.

EXPERIMENT DOG 31. Operation, November 17, 1915. Transverse incision. Defect in bladder accidentally made somewhat larger than fascia lata removed to fill it. Fascia measured 3½ x 2¼ centimeters and was sutured in place under considerable tension. Reinforcing sutures were desirable, could not be placed without narrowing the defect; therefore were not employed. Unusual oozing from cut edge of bladder and of abdominal incision noted at operation.

Postoperative course. Uneventful convalescence. Normal course until January 29, when stools became tarry. Fresh active bleeding from the bowel followed, and the dog succumbed on January 31, two and a half months after operation.

Postmortem examination. Tissues very anæmic. Stomach and intestines filled with old and fresh blood. Source of the hæmorrhage was not found. Peritoneal cavity negative. Omentum broadly adherent at site of operation on the bladder. Latter greatly distended. Silk sutures outlined a circular area approximately the size of the original defect. Peritoneal surface of tissue filling defect not visible through omentum. Viewed from interior, a smooth bony plaque about 2 x 2 centimeters is seen occupying the center of the transplanted area, covered by a thin translucent layer of tissue continuous with the mucous membrane.

Microscopic examination. Surgical Pathology No. 3827. The marrow spaces that are present in the plaque of bone which had formed are easily seen with the naked eye. Microscopically very large blood-vessels as well as numerous small ones are found in the loose-meshed tissue of these spaces. The elongated mass of bone occupies most of the free surface of the original defect, is covered by a continuous layer of epithelium and ensheathed by a connective-tissue layer remarkably like periosteum. This is the only specimen which showed a second independent deposit of bone, in the depths of the cicatricial tissue occupying the defect. Smooth muscle spreads in a thin layer across the defect as in the previous experiments.

EXPERIMENT DOG 115. Large male. Opera-

tion, December 10, 1913. Incision in right hypogastrium. Epigastric vessels ligated. Defect in bladder 2½ x 2½ centimeters, replaced by fascia from abdominal wall measuring 3 x 3 centimeters. Several reinforcing sutures. Layer suture of abdominal incision.

Postoperative course. Temperature 101° to 102° for two days, normal thereafter. Some blood in urine the day after operation. Animal chloroformed March 6, 1914, three months after operation.

Postmortem examination. Bladder moderately full. Thin strand of omentum firmly attached at site of operation. The latter is the seat of a rather anæmic, firm, smooth plaque of tissue. Examined from the interior the plaque is bone-like in a small area, very hard, apparently not bony in the remainder. Mucous membrane appears to cover this, as noted in previous experiments. No reduction of bladder capacity. Kidneys and ureters negative.

Microscopic examination. Surgical Pathology No. 2895. A very large area of bone smooth at the periphery occupies most of the free surface of the defect. Epithelial overgrowth is peculiar in the heaped-up islands seen here and there. Otherwise the findings are similar to those already noted.

EXPERIMENT DOG 26. Small female. Operation, November 11, 1915. Transverse incision. Circular defect of bladder around vertex, 3½ x 2 centimeters, replaced by a sheet of fascia lata slightly larger.

Postoperative course. Uneventful. Animal chloroformed February 8, 1916, three months after operation.

Postmortem examination. Bladder empty. Thin strand of omentum firmly adherent to it in operative field. The entire vertex of the bladder the seat of a very resistant plaque of tissue, the size of the original defect, outlined by the black silk sutures. Inspected from within the bony character of this tissue is evident. Mucous membrane completely covers the region of the transplant. No shrinkage of bladder capacity.

Microscopic examination. Surgical Pathology No. 3844. The bone plaque is remarkable for its unusual length, almost completely that of the defect (as shown by the position of the silk sutures). Very many osteoblasts and osteoclasts are seen. The ensheathing periosteum-like tissue is unusually well defined. Epithelial and smooth muscle overgrowth as in previous specimens.

EXPERIMENT DOG 262. Female, medium size. Operation, March 26, 1914. Bladder empty. Defect 3 x 2 centimeters replaced by fascia lata in the usual way. No reinforcing sutures. Hæmatoma in bladder-wall near cut edge not ligated. Considerable oozing from incised bladder-wall.

Postoperative course. Normal. Animal sacrificed with chloroform July 26, four months after operation.

Postmortem examination. Bladder almost empty. Broad omental adhesion at site of transplantation. The latter not seen clearly through the omentum. The interior of bladder at site of operation revealed a number of silk sutures dangling free, not surrounded by incrustations. The sutures outlined an area almost equaling the original defect in size. A very large plaque of bone the entire length of the original defect and about half its width. Projecting from its base are three broad spurs of bony tissue, fused at their attachment but sharply hooked and covered with minute spines at their tips. Mucous membrane appears to cover the entire bony mass, except, perhaps, at the very tips of the spurs.

Microscopic examination. Surgical Pathology No. 3612. The only unusual feature is the extreme development of the bone-marrow. The marrow spaces are enormous in proportion to the ridges of bone that surround them. They are richly vascular, full of the typical cells of bone-marrow enmeshed in the typical network of areolar tissue. Complete overgrowth of epithelium and of smooth muscle.

The only experiment in which perforation through and leakage from the bladder occurred was as follows:

EXPERIMENT DOG 261. Average-sized male. Operation, April 8, 1914. Vertical incision in right hypogastrium. Vessels in bladder-wall going to the outlined defect were very large and were ligated a short distance from the line of excision. Bladder moderately full so that *five-eights of wall* could be fairly well estimated. This was replaced by fascia from the abdominal wall by the usual technique. Layer suture of wound.

Postoperative course. Uneventful until second day then evidences of peritonitis. Death four days after operation.

Postmortem examination. Generalized peritonitis from leakage from bladder through ragged perforation near center of transplant. The part of fascia nearer the suture line appeared well preserved, union at suture line strong. The healthier appearance shaded insensibly to the necrotic at the perforation. Bladder empty. Interior deeply congested.

Fat transplants were sutured into vesical defects in a few experiments, in an attempt to determine (1) if tissues other than fascia could be satisfactorily employed for the purpose, and (2) if bone would develop under such circumstances. Although leakage did not occur, the functional results were unsatisfactory. It was found that extrusion of the fatty tissue into the bladder took place, and that the lips of the defect of the bladder drew together as the transplant was expelled. The results were a diminution in bladder capacity and the formation of vesical calculi, to an enormous extent in one instance. Lime de-

posits, similar in distribution to those seen after fascia transplantation, were found in the bladder wall, at the site of the defect, soon after operation. The early stages of bone formation were also seen, in a specimen examined a somewhat longer time after operation. It is therefore fair to assume that, if the defects had not become obliterated or if the experiments were continued for a sufficiently long time, extensive bone development identical with that after fascia transplantation, would have taken place.

EXPERIMENT DOG 340. Young male of good size. Operation, May 7, 1914. Transverse incision. Fat from right side of abdominal wound 3½ x 3½ centimeters. Removed and sutured into a 3½ x 3 centimeters defect in the usual way. The fat could not be as easily handled as fascia, but sutures held very well in it. Several additional stitches required to tack down loose ends of the fatty tissue. Layer suture of wound.

Postoperative course. Uneventful until the development of distemper for which reason animal was chloroformed on May 19, twelve days after operation.

Postmortem examination. Extensive omental adhesion at site of operation on bladder; the underlying tissues not visible. Bladder moderately full, no evidence of leakage. Viewed from interior, a considerable mass of calcareous material is found loosely attached at the field of operation. After its removal the projection of the fatty mass into the lumen is seen. Mucosa apparently has partly grown over the defect.

Microscopic examination. Surgical Pathology No. 3506. A mass of areolar tissue fills the defect. Its free surface is composed of numerous shreds of fat, some slightly, some almost completely detached. Its deeper layers are crowded with polynuclear leucocytes and small round cells. Deposits of lime are seen, not only between fat-cells near the surface, but also in larger masses in the depths. The bladder-wall stops abruptly at the margin of the defect. Here the bladder epithelium dips deep between transplant and bladder-wall, but shows evidence at only one point of attempted extension across the site of the defect. Bladder-wall and transplant fuse intimately. Omentum is attached to the deep surface of the fatty tissue.

EXPERIMENT DOG 325. Female of medium size. Operation, April 30, 1915. Transverse hypogastric incision. Fat between mammary glands, with possibly a narrow strip of gland on each side, excised. Its surface measurement was 4 x 4 centimeters, thickness varied from ½ to 1¼ centimeters. Defect in anterosuperior wall of bladder was 4 x 4 centimeters. Fat sutured in place without difficulty. Oozing from cut bladder-wall did not appear to be as well controlled by contact with transplant as in fascia transplantations. Layer suture of abdominal wound.

Postoperative course. Uneventful except for frequent urination noted after the second week. Animal chloroformed July 19, two and a half months after operation.

Postmortem examination. Fine omental adhesion to bladder at site of operation. Underneath it the wall of the bladder deeply congested, no evidence of any new tissue filling defect. Although tense with contained urine, bladder was small, could not be made appreciably larger by water distention; capacity manifestly greatly reduced. Occupying almost the whole interior of the bladder is an enormous, mulberry-shaped calculus. This is found to be built about the disintegrated, extruded fat transplant. After its removal, mucous membrane was found entirely covering site of the defect. Its appearance not normal, deep red, injected and raised into fine papilloma-like projections at several points.

Microscopic examination. Surgical Pathology, No. 3613. The site of the defect cannot be distinguished. There are no traces of the transplant which, as was seen above, had extruded into the bladder. The musculature of the bladder-wall has united at the defect in the form of large bundles irregularly interlaced. The free surface of the bladder-wall at the site of the defect is occupied by many large papillomatous projections rich in blood-vessels and young connective tissue and covered by a dense uniform layer of epithelium. Near the surface and in the depths deposits of lime are seen. In a few places the earliest stages of bone formation are seen, small islands of deeply-staining tissue arranged about cells in a trabeculated fashion. The adherent omentum contains many blood-vessels.

It remains for the future to determine the practical possibilities of fascia transplantation into vesical defects. The procedure may prove of value in some of the difficult problems of bladder surgery: vesical exstrophy, closure of defects after extensive resection, large vesicovaginal fistulæ, etc.

The process of tissue repair after experimental fascia replacement of bladder defects is of considerable interest. In the first place, it is adequate. Granulation tissue disappears soon after operation, fusion between the tissues of the defect and those of the bladder-wall is complete, epithelial overgrowth is complete at an early stage. The newly formed bladder-wall is as strong as or stronger than the remainder, contracts to an insignificant extent (if at all), does not lead to the formation of vesical calculi. These characteristics are quite uniform throughout all

the experiments. I wish to dwell upon two remarkable developments noted in the processes of tissue repair; bone formation in the defect and smooth muscle growth across the defect.

It is out of place to enter here into the whole question of the tissues required for bone development. That previous bone or periosteum is not necessary for the formation of new osseous tissue, was, of course, demonstrated by finding such tissue developed in situations far removed from the skeletal system. The experiments I have reported show clearly that the bone deposits occurred with concretions of lime as their beginnings, without any relation to blood-vessels, or to any of the tissues of the adjoining bladder-wall. Except for the necessary nourishment to the tissues repairing the vesical defect, it might almost be said that the development of bone took place, in this situation, outside the body. This is further emphasized by the fact that the deposit of bone was invariably limited to the site of the defect. The suggested possibility that fascia, genetically related to bone, was transformed into that tissue, is manifestly invalidated by the fact that lime deposits and bone formation appeared when fat was transplanted. Furthermore, it is to be noted that the fascia degenerates at an early stage, before the bone development is well on its way.

The evolution of bone in these experiments can be explained, therefore, only by the metaplasia of any connective tissue occupying the defect. That it was a development that may, in a sense, be termed "normal" for the existing conditions, is shown by its presence in every experiment. The reasons for, and the way in which, bone is laid down appear to me to be as follows: The tissue occupying the defect is constantly being subjected to great tension. The defect being too large to permit obliteration, reinforcement for the tissues filling the gap is desirable. A favorable opportunity to obtain reinforcement exists potentially in the presence of calcium salts in solution in the urine. These are laid down on the surface and are taken up in the depths of the transplant by imbibition. The lime deposits stimulate the surrounding connective tissue chemically or physically (or chemicophysically) to build up the most powerful barrier. Bone deposits are the result, with lime salts as their actual nuclei or their centers of stimulation. It is in this way that the microscopic findings in the experiments are best understood. Furthermore, one can realize why the astonishingly early development of bone was not a degenerative phenomenon.

The periosteum-like layer ensheathing the bone plaques can be accounted for satisfactorily on the theory of metaplasia of adjoining connective tissue, and similarly, metaplastic changes in connective tissue included between bone trabeculæ will explain the development of bone-marrow. However, the appearance of cartilage in one experiment cannot be accounted for readily in this way. The fact that cartilage developed only once appears to require, in itself, a different hypothesis. It is true that the appearance of the large deposit of cartilage, situated in a cup-like hollow in the bone, may be ascribed to metaplasia of connective tissue filling the cavity. The suggestion is evidently forced, however, for hollows in the other specimens of bone do not reveal cartilage. Furthermore, it cannot account for the scattering of the cartilage-cells in the adjacent bony mass and, above all, for the scattering of islands of cartilage-cells at widely separated points throughout the bone plaque. An adequate explanation cannot be offered. There appear to be only two possibilities; either bone was converted into cartilage or cartilage into bone. The latter would, of course, be in accord with a widely held view, but is not quite adaptable to the findings. Cartilage was not laid down in any of the other experiments, and in this specimen does not present the picture seen when cartilage is being replaced by bone. In support of the opposite hypothesis, it might be urged that, in the specimen in question, the sharp projecting prongs of bone at the end of the plaque made friction with the adjoining bladder-wall; in an effort to overcome this the development of cartilage was in the nature of a closely related tissue adaptation of the active growth of bone. Even if this were true, however, it does not account for the islands of cartilage scattered in the bone. The best suggestion that can be offered

at the present time is that, in this experiment, cartilage was orginally laid down, as in the embryo, and that it was gradually replaced by bone, as in postnatal life.

The presence of muscle bridging the defects will now be considered. I believe that the specimens offer conclusive evidence of the regeneration of smooth muscle. This question has been discussed for many years. The presentation of arguments based on the work that has been done in the past would lead too far afield. It will suffice to say that the generally held view at the present time is that smooth muscle regenerates little or not at all.

The large defects that were made in the bladder offered an unusual opportunity to investigate the question anew. The tissue found in the defects was undoubtedly smooth muscle.[1] It was characteristic in staining qualities, in the shapes and arrangement of the cells, in the long narrow nuclei; and was continuous with the smooth muscle of the bladder-wall on either side of the defect. The development of the smooth muscle in the defect can be traced in the chronological arrangement of the experiments. In examinations soon after operation, practically the whole muscle-wall stopped abruptly at the margin, only a few fibers extending short distances into the defect. At later stages bundles of muscle extended well into the defect, to make a neat, thin, continuous layer of muscle or an irregular, ill-defined layer of interlacing bundles in the latest stages. It is certain that the defects contracted little if at all, and that strips of muscle were not left attached when the defects were made. Only by the development of new muscle-bundles can the layer of smooth muscle found across the defect be explained. Evidences of smooth muscle regeneration were seen after defects made in some of the other hollow viscera but, because they were inconclusive, no further reference need be made to them.

2. TRANSPLANTATION OF FASCIA INTO URETHRAL DEFECTS

The experimental work of Kostenko and Rubaschew indicates that fascia transplantation *over suture lines* in the ureter is not a reliable procedure, for leakage of urine followed in several instances. In one experiment, however, at which an end-to-end anastomosis of the divided ureter was made and surrounded by a cuff of fascia, it was found that the suture lines in the ureter had separated and that the fascia was the only barrier to successfully prevent the escape of urine. Clinically, however, a case was reported by these authors in which fascia placed over the sutured ureter (after removal of a calculus) did not prevent leakage.

The clinical problem of replacement of ureteral defects has not been solved. Nephrectomy must be performed if end-to-end suture is impossible and the upper end of the divided ureter cannot be implanted into the bladder. It is, therefore, surprising to find that so few experimental efforts have been made in this field. Owing to the resistant qualities of fascia, I believe that tubes made of this material might satisfactorily replace ureteral defects. Although there is not a single completely successful experiment to support the view that the procedure is practicable, and possibly clinically applicable, it is nevertheless, maintained, for the failures encountered depended on several factors that can be eliminated: (1) The ureters in the dog are of very small caliber; (2) faulty technique; (3) inability to obliterate permanently the "dead space" left after extraperitoneal exposure of the ureter. Additional experience may obviate these difficulties.

The best experimental results were obtained when a tube of fascia was first constructed around a glass rod in the thigh and was transferred to the ureteral defect two weeks later. In three experiments in which this was done, there was absolutely no leakage. Unfortunately the animals died too soon after operation (one from hæmorrhage, two from unknown causes), to determine if a permanently satisfactory result would have been obtained. The description of a single experiment will suffice to illustrate the technique.

EXPERIMENT DOG 342. Male, medium size. *First operation*, June 10, 1914. Fascia lata exposed in left thigh. Glass rod, smooth at both ends,

[1] Drs. Clarke, McWhorter, and Sharp, of the Columbia University, College of Physicians and Surgeons, kindly corroborated this statement.

approximately the diameter of the ureter, dipped in vaseline, placed over fascia. Latter incised on either side of rod, sutured snugly over it with very fine silk. Subcutaneous tissue and skin sutured.

Second operation, June 25. Left ureter exposed extraperitoneally by an incision through the lateral abdominal musculature. Middle part of ureter isolated, the vessel running alongside ligated above and below, 5 centimeters resected. Field of first operation exposed. Glass rod found loose, and removed. Fascia tube made complete by freeing both ends and ligating them. The tube then measured 7 centimeters. Small slits were cut into it at each end near the ligatures. The ends of the ureters were drawn through the slits and fastened within the tube, as seen in the accompanying diagram. Layer suture of the wound.

Postoperative course. Nothing abnormal noted. Four days after operation the dog was found dead in his cage.

Postmortem examination. Cause for death could not be ascertained. Wound solid, no leakage of urine. Peritoneal cavity intact. Kidneys negative. Ends of ureters firmly fixed in fascial tube. Probe passed readily from above through ureter into the tube and the lower end of the ureter. Water injected from above passed through without difficulty.

The results of all the experiments in which the fascial tube was built around the ureteral defect were unqualified failures. Death followed either from leakage and infection or from hæmorrhage into the wound. In one instance the hæmorrhage was only moderate and the anatomical result of the operation was satisfactory. This experiment will be reported and the technique of construction of a fascial tube *in situ* will be described.

EXPERIMENT DOG 266. Operation, April 10, 1914. Extraperitoneal exposure of middle portion of the left ureter. Isolated, 2½ centimeters excised. Vessels accompanying ureter not ligated to avoid compromising the lumen. Anterior lips of cut ends of ureter slit up a few millimeters. Sheet of fascia lata of suitable size, held by tension sutures, placed under the defect. Posterior lips of ureter ends fixed to fascia at two points each, by passing double-threaded sutures and tying knots on outside of fascia. The upper pair of guide sutures in the fascia brought together, then the lower pair. The two edges of the fascia then sutured (continuous fine silk) to make the tube. Before latter was complete, above and below, double-threaded sutures were passed from anterior lips of ureter ends through fascia, knots on the outside. The sutures were so placed that, when drawn taut and knotted, the cut ends of the ureter would be held wide open. The fascia tube suture completed above and below by being carried over ureter and sutured to its wall. Additional stitches all around from end of fascia tube to ureter wall, fixed the tube firmly in place. Layer suture of the wound.

Postoperative course. Condition good immediately after operation. Gradually deteriorated. Death April 14.

Postmortem examination. Moderate hæmorrhage into the extraperitoneal space. Source apparently the vessel accompanying ureter. No blood in the urine-filled bladder. Anastomosis intact. Probe and fluid pass through readily from above downward. Viewed from within, the lips of the ureter fit snugly against fascia tube.

3. FASCIA TRANSPLANTATION INTO ŒSOPHAGEAL DEFECTS

Brief reference has already been made to the experiments performed by Koenig and by Hohmeier, in reinforcing suture lines of the œsophagus. Kostenko and Rubaschew reviewed their work in a considerable number of experiments. They found that the transplant could be depended upon almost invariably to prevent leakage from such suture lines. On the other hand, necrosis and perforation of the fascia followed all their attempts to replace appreciable defects — 2 x 2 centimeters or more — of all the layers of the organ.[1] There were *occasional* successes in their efforts to bridge very small œsophageal fistulæ by fascia transplants; they were found to depend upon obliteration of the defect and not upon upbuilding of new tissue in it. All these observations have no further practical significance than to suggest that suture lines in the œsophagus can be reinforced satisfactorily by fixing fascia strips over them. In short, it was as incorrect to say that experimental defects of the œsophagus have been satisfactorily bridged by fascia as it was to make such statements concerning vesical defects.

Despite these experiences, it was thought that, with the modifications of technique that have been described, large defects might be successfully replaced by fascia transplants. It was essential, however, that little or no œsophageal stenosis should follow; otherwise the procedure would be no better, less desirable, in fact, than ordinary suture or plastic methods. Only a few experiments were necessary to demonstrate that large defects,

[1] Histological examinations are not reported in any of these experiments.

involving as much as the entire anterior aspect of the œsophagus, could be satisfactorily bridged in this way. The results were good anatomically and functionally. Slight stenosis was observed in an experiment concluded two weeks after operation; this was less evident in an experiment ended three weeks after operation, and was almost imperceptible four weeks after operation. In view of the more infected state of the animal œsophagus, the unavoidable movements of the head and neck after operation, and the necessary administration of nourishment by mouth soon after operation, it appears correct to believe that the expectation of success after fascial transplants into œsophageal defects in the human subject can be even greater than in the experiment. The present-day treatment of small œsophageal fistulæ is simple and efficient. The attempt to close larger defects (as after excision of a diverticulum, sloughing from impacted foreign body, etc.) involves complicated plastic procedures, the average results of which cannot be termed very satisfactory. It remains for the future to determine if fascia transplantation, technically very simple, can offer better results.

The experimental results I have obtained are seen in the descriptions that follow. Granulation tissue appeared on the surface of the transplant soon after operation. In the later stages the defect was found solidly filled by connective tissue (representing the altered fascia), partly contracted, and entirely covered by epithelial overgrowth.

Experiment Dog 157. Female, medium size. Operation, March 1, 1916. Longitudinal incision slightly to left of midline of neck. Musculature split over trachea. Latter retracted. Œsophagus exposed and isolated about 5 centimeters below level of thyroid cartilage. Left vagus dissected from wall and drawn aside. Defect 4 x 2½ centimeters made in anterior wall, long axis in that of œsophagus. Mucus sponged away. Bleeding vessels not ligated. Fascia lata, slightly larger than defect, sutured in place. A few reinforcing sutures. Layer suture of wound.

Postoperative course. Fluid diet for first week. Animal considerably emaciated at end of that time. Improved promptly with soft diet. Chloroformed March 17, sixteen days after operation.

Postmortem examination. Pericœsophageal connective tissue extensively adherent at site of operation. In this situation œsophageal wall felt infiltrated. No evidence of stenosis with œsophagus *in situ*. After removal of specimen and marked distention with fluid, slight stenosis noted at level of transplant.

Inspection of interior: many silk sutures hanging free. After their removal a central irregular elevation of tissue noted at site of transplant. Surrounding it a narrow, smoothly covered hollow. Beyond that the mucous membrane, thrown up in definite ridges toward the defect, merging gradually into the normal œsophageal lining in the opposite direction. The whole patch of abnormal tissue measured 3 x 1½ centimeters.

Microscopic examination. Surgical Pathology No. 3884. The transplanted fascia is broken up into bundles undergoing hyaline degeneration. On both sides of the defect these fuse with the mucosa and muscularis, the physical union evidently being very close. There are many blood-vessels (filled with red cells) in the fascia layer about the middle, fewer toward the periphery, of the defect. The free surface of the fascia is covered by a thick layer of organizing granulation tissue. Over this the epithelium overgrowth is complete. The layer composed of granulation tissue plus epithelium is raised in villus-like folds, the free ends of which appear very fragile (absent in several places in the stained specimens). The deep surface of the transplant is covered by a thick layer of young connective tissue.

Experiment Dog 150. Male, fair size. Operation, February 23, 1916. Œsophagus exposed as in previous experiment, at a somewhat higher level. Left thyroid lobe retracted, inferior thyroid vessels ligated. Left vagus and carotid vessels isolated and drawn aside. Section of lateral wall of œsophagus, 2½ x 3½ centimeters, removed. Replaced by fascia lata. Several reinforcing sutures. Wound closed in layers.

Postoperative course. Fluids for one week; soft diet thereafter. Emaciation, considerable at the outset, never disappeared. Animal in very good condition, however. Chloroformed March 17, twenty-three days after operation.

Postmortem examination. Slight puckering and stenosis of œsophagus at site of transplantation. Surrounding connective tissue adherent. Œsophageal wall felt firmer here than elsewhere. Stenosis evidently very slight, as tested by water distention.

Inspection of interior: Silk sutures hanging loose, were removed. Irregular ridge, 2½ centimeters long, narrow for the most part, at site of defect. It is elevated into small knobs here and there. Mucous membrane appears to stop at the bottom of the ridge, the covering of the latter being a smooth, translucent, thin layer of tissue of distinctly different appearance from normal mucous membrane.

Microscopic examination. Surgical Pathology No. 3883. The defect is partly drawn together at the free surface, where it is covered over by a complete layer of epithelium thrown into low ridges.

The defect is drawn together to a lesser degree in the depths, where it is filled by a thick layer of connective tissue barely recognizable as fascia undergoing hyaline degeneration and fibrous tissue replacement. Muscle bundles from the œsophageal wall are numerous and neatly arranged toward the margin of the defect, interlace irregularly and gradually thin out toward its middle. Fusion of muscle and connective tissue. There are many large blood-vessels throughout the tissue filling the defect, but no granulation tissue is to be seen.

EXPERIMENT DOG 143. Male, good size. Operation, February 16, 1916. Exposure of lower third of œsophagus. Isolated from trachea and left vagus. Section of anterolateral wall 3½ x 2 centimeters removed. Replaced by fascia in the usual manner. No reinforcing sutures. Layer suture of wound.

Postoperative course. Fluids for one week, soft diet thereafter. Emaciation, extreme at outset, did not entirely disappear. General condition excellent, however. Chloroformed March 17, one month after operation.

Postmortem examination. Thin adhesions to site of operation, which is otherwise indistringuishable. No sign of stenosis with œsophagus *in situ*. When removed and submitted to maximal fluid distention, very slight stenosis is visible. Viewed from the interior, an almost imperceptible, slightly elevated cicatrix 2½ centimeters long, a few millimeters to 1 centimeter wide; covered by smooth, shining tissue continuous with œsophageal mucous membrane.

Microscopic examination. Surgical Pathology No. 3882. Complete epithelial overgrowth. The defect is filled by a thick mass of connective tissue in which a fascial structure is not discernible. Muscle-bundles extend into and fuse with this layer, thinning out as the center of the defect is approached. The tissues of the defect pass over, by insensible gradations, into those of the œsophageal wall, only the mucous glands in the latter suggesting the line of demarcation.

4. TRANSPLANTATION OF FASCIA INTO GASTRIC DEFECTS

Attention has been called to the attempts by various experimenters to support suture lines of the stomach by transplanting strips of fascia over them. The experiments have not demonstrated clearly that this procedure offers definite assurance of additional reinforcement. Attempts to replace all the layers of the stomach have failed invariably, even when the defects were very small.

These attempts were repeated by me with the described modification in technique, in a number of experiments, because there appeared to be some possible clinical applications in gastric surgery if the experiments proved successful. Failure followed in every instance. Perforation through the necrotic transplant always occurred, no matter what technique was employed. Apparently the transplanted fascia was attacked by the gastric juice and its disintegration promptly followed. This view was supported by the fact that the perforation was almost invariably a smaller or larger one near the center of the transplant, and not a separation of the suture lines. Indeed, intact suture lines between stomach and transplant, with relatively intact fascia adjacent to them, were encountered in several of the experiments. The details of all the experiments are unnecessary. The following will serve as examples:

EXPERIMENT DOG 136. Operation, December 24, 1913. Defects 3 x 2 centimeters near pylorus, sheet of fascia from the abdominal wall, slightly larger, implanted into it. Death within twenty-four hours from perforative peritonitis. Transplant almost completely gone. Only a thin fringe found attached at the suture line.

EXPERIMENT DOG 73. Operation, November 12, 1913. Defect 4 x 3 centimeters on anterior surface of stomach. Excess mucosa removed. Fascia transplant slightly larger. Several reinforcing sutures. Death two days after operation. Small perforation through center of transplant, generalized peritonitis. Omentum adherent to fascia around the perforation. Viewed from within, smooth, firm union of gastric wall and transplant. Mucosa congested near the suture line.

Finding these efforts to replace gastric defects by fascia quite futile, it appeared of interest, in relation to experiences in the human being, to inquire if gastro-enterostomy would in any way influence the result. The most generally practiced operation for perforated gastric ulcer is suture of the ulcer and gastro-enterostomy. Exclusion of the pylorus is added by some surgeons. On the other hand, some observers believe that gastro-enterostomy is not essential or even desirable in the treatment of perforated gastric ulcer, especially because it has been demonstrated that gastro-enterostomy does not deflect the gastric contents from the site of a sutured ulcer near the pylorus. Turning to the experiments I performed, they consisted in the addition of gastro-enterostomy,

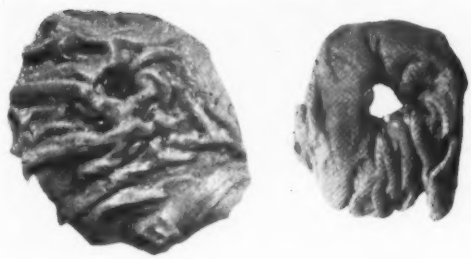

Fig. 29, A (at left). Small perforation through center of fascia transplant in defect of stomach indicated by probe. B. Large perforation in transplant into gastric defect, firm union between remnant of fascia and adjoining wall of stomach. (The cross hatching is due to gauze against which the specimen was pressed.)

with and without pyloric exclusion, to the fascia replacement of defects near the pylorus. They demonstrate clearly that gastro-enterostomy does play an important rôle, has a profound influence upon the result, for the fascia transplant healed in place invariably when gastro-enterostomy was added. Exclusion of the pylorus was manifestly not a factor, for the results were entirely satisfactory without any attempt at its practice. The contrast between the previous group of experiments, in which failure followed every effort at fascia replacement of gastric defects, and this group, in which fascia replacement was always successful when gastro-enterostomy was added, is very impressive.

Two illustrative experiments follow, one with and one without pyloric exclusion. A remarkable feature of the first was the formation of true bone in the tissues at the site of the defect. This is merely mentioned here, for the question of bone formation was considered in detail in the section devoted to fascia transplantation into bladder defects. The conditions were analogous except that, in the bladder experiments, the necessary calcium salts were of course much more readily accessible.

EXPERIMENT DOG 207. Large male. Operation, April 5, 1916. Incision in right hypochondrium. With its center about 6 centimeters from the pylorus an oval defect 4 x 2½ centimeters was made. Defect replaced by a slightly larger sheet of fascia, usual technique, six reinforcing sutures. No loop gastro-enterostomy.

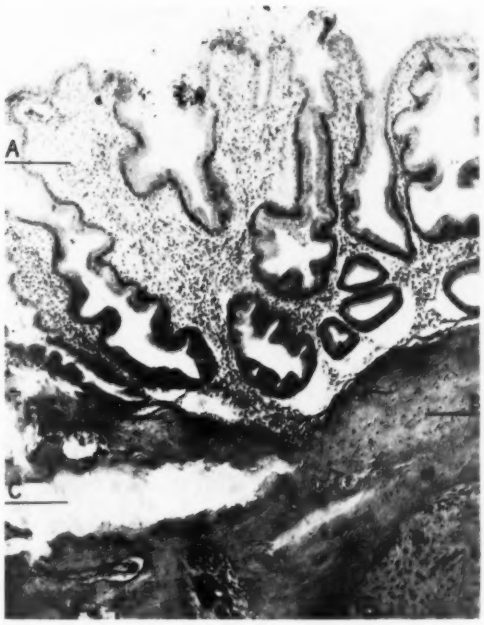

Fig. 30. Pathology No. 4007. Eight weeks after fascia transplant into defect of stomach. Photograph from periphery of filled defect. *A*, Well-developed mucosa resting directly on bone plaque, *B; C*, artefact.

Postoperative course. Fluids for one week, soft diet for two weeks, ordinary food thereafter. Animal always in splendid condition. Chloroformed June first, eight weeks after operation.

Postmortem examination. Gastro-enteric stoma and pylorus open. Omentum adherent at site of transplant so that the external surface could not be seen. No sign of weakness upon extreme fluid distention of the clamped-off stomach. Viewed from within, the field of operation was a somewhat depressed area about 2 x 3 centimeters, smoothly covered over by gastric mucous membrane.

Microscopic examination. Surgical Pathology No. 4007. Intimate fusion between the tissues occupying the defect and the adjoining gastric wall. No evidence of the transplanted fascia as such. It is replaced by a closely woven mass of connective tissue. Embedded near its free surface is a macroscopic plaque of bone with many small marrow-spaces, numerous osteoblasts, occasional osteoclasts, and a fairly well-developed limiting, periosteum-like sheath. The deposit of bone is sharply limited to the site of the defect. The free surface of the latter is completely covered by the overgrown gastric mucosa. This is seen in varying stages of development, from the mature layer at the periphery of the defect, to the low, irregularly laid down villi toward the center.

Fig. 31. Pathology No. 4007. Eight weeks after fascia transplant into defect of stomach. Photograph from region toward center of defect. *A*, *A*, Incompletely developed mucosa; *B*, bone plaque with periosteum-like layer, *C*, *C*; *D*, connective tissue in remainder of defect.

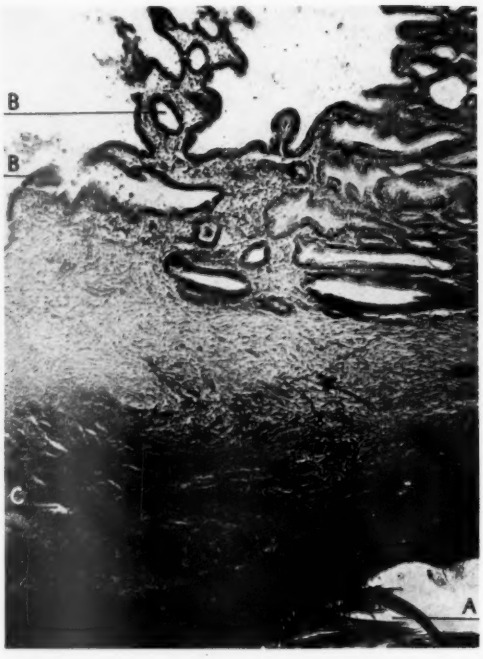

Fig. 32. Pathology No. 3900. Fifteen days after fascia transplant into defect of stomach. *A*, Silk suture indicating line of transition; *B*, *B*, atypical mucous membrane growing over organized granulation tissue of defect; *C*, degenerating fascia.

EXPERIMENT DOG 166. Good sized male. Operation, March 8, 1916. Epigastric incision. About 5 centimeters from the pylorus a defect 2 x 3 centimeters was made. Excess mucous membrane excised. Replaced by a slightly larger sheet of fascia with usual technique. To make it more secure, the edge of the fascia, wherever it projected between the sutures, was attached to the adjoining gastric serosa by a second tier of sutures. Ordinary short loop gastro-enterostomy. Pylorus ligated with stout silk. Layer suture of the wound.

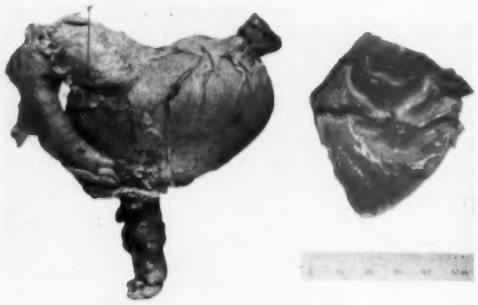

Fig. 33. Fifteen days after fascia transplant into gastric defect. A (at left). Arrow points to site of transplantation, to which an irregular patch of omentum is adherent. The gastro-enterostomy and incomplete pyloric occlusion are seen. B. Appearance of interior of stomach at the transplanted area.

Postoperative course. Fluids for one week, soft diet thereafter. Animal in excellent condition. Chloroformed March 23, fifteen days after operation.

Postmortem examination. Pyloric occlusion incomplete. Gastro-enteric stoma patent. The extreme left margin of liver, surrounded by a thin strand of omentum, adherent at site of transplantation. After their detachment, the gastric wall underneath was found to be the seat of a firm plaque, not very sharply circumscribed, about 2 x 2 centimeters.

Microscopic examination. Surgical Pathology No. 3900. Firm union between tissues filling defect and adjoining stomach-wall. The transplanted fascia has undergone considerable *hyaline degenera-*

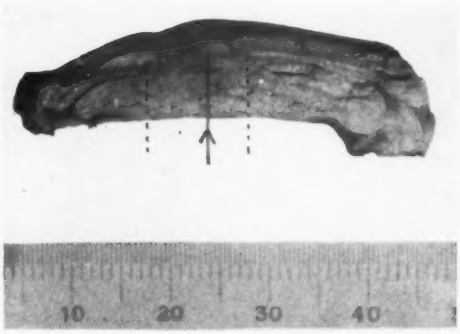

Fig. 34. Pathology No. 2685. Cross section of small intestine through transplant, one month after operation. Arrow points to the tissue occupying the defect, the dotted lines indicating the abrupt termination of the intestinal wall at the defect.

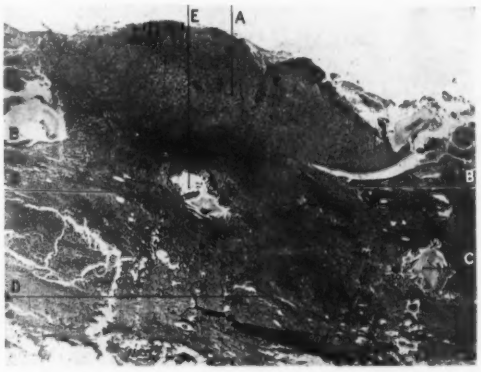

Fig. 35. Pathology No. 2685. One month after fascia transplant into defect of small intestine. *A*, Organizing granulation; *B*, *B* margin of wall of intestine, indicated on one side by silk suture, *C*; *D*, *D*, remnants of degenerating fascia; *E*, artefact.

tion. Its deep surface is covered by a layer of connective tissue, to which omentum is adherent. Its free surface is covered by a layer of organizing granulation tissue, over which the gastric mucous membrane has in part grown, in an atypical fashion.

5. FASCIA TRANSPLANTATIONS INTO DEFECTS OF THE SMALL AND LARGE INTESTINE

Reinforcement of suture lines in the intestinal wall has been attempted, both clinically and experimentally, with varying results that have already been mentioned. No effort has been made to replace actual defects in either the large or small intestine. For the reasons that have been advanced in the first part of this paper, it was of interest to determine if such procedures could be successfully carried out. The following results were obtained: Transplants into defects in the upper part of the small intestine generally failed. Small transplants in the lower part of the small intestine were often successful, but the replacement of larger defects not infrequently failed. On the contrary, fascia implantation into these larger defects in the large intestine succeeded in two out of three experiments. In short, there have been failures after transplants into defects of small and large intestine of about the same size as those that have been successfully bridged. These results indicate that, though occasionally successful, fascia transplantations into intestinal defects is not a very reliable procedure. The results are not comparable with those obtained in the œsophageal and vesical defects or in the tracheal defects to be described. Yet the possible practical application must be considered in some of the difficult problems that are encountered in urgent abdominal surgery.

The technique employed was the same as in the other groups of experiments; implantation *into* and not *over* the defects. Microscopic

Fig. 36. Pathology No. 2685. One month after fascia transplant into defect of small intestine. Showing epithelium growing over granulation tissue and transition from intestinal wall to tissues of defect.

Fig. 37. Pathology No. 2932. Five weeks after fascia transplant into defect of large intestine.

examinations revealed some shrinkage of the defect but very slight or no stenosis was visible in the gross specimens. As will be seen in the following experiments, granulation tissue appeared on the free surface and between the bundles of the disintegrated transplant. The intestinal mucosa grew in part over this granulation tissue but in no instance completely across, in the relatively limited periods of observation after operation.

EXPERIMENT DOG 63. Small male. Operation. November 5, 1913. Median epigastric incision. Loop of small intestine, about 8 centimeters above ileocolic junction, drawn out of wound, intestinal clamps applied above and below. The intestinal wall contracted to a flat ribbon-like band, so that determination of size of defect was difficult. An elliptical section, 3 x 1½ centimeters removed, the long axis in the long axis of the intestinal canal. Slightly larger sheet of fascia from the abdominal wall sutured into defect in the usual manner. Slightly overhanging edges of transplant attached to adjoining intestinal wall by a number of Lembert sutures. After removal of clamps, no leakage. Spasm of intestine disappeared and actual defect measured. It was 2¼ x 1¾ centimeters, opposite the mesentery, and involved more than half the circumference of the bowel. Suture of the abdominal incision.

Postoperative course. Temperature between 101° and 103° for four days, normal thereafter. No evidences of peritonitis. Animal in good condition. Sacrificed with chloroform December 1, four weeks after operation.

Postmortem examination. No signs of peritonitis. Omentum adherent to intestine in region of operation. No evidence of stenosis upon inspection or distention of the bowel with water. No bulging at field of operation with considerable water pressure. Inspected from within, a slight constriction of the lumen appears to exist. The site of transplantation slightly elevated, appeared smooth and apparently covered in part by mucosa.

Fig. 38. Pathology No. 2932. Five weeks after fascia transplant into defect of large intestine. *A*, Epithelium covering organized granulation tissue, *B; C*, connective tissue intermingled with remnants of fascia, *D; E*, muscle fibers extending into defect; *F*, omentum.

Microscopic examination. Surgical Pathology No. 2685. Defect smaller than at operation, its free surface occupied by organizing granulation tissue. This goes over, in a relatively sharp line, into neighboring muscularis, submucosa, and mucosa. Small fragments of transplanted fascia about silk sutures in the depths. Adjacent to serosa is a thick layer of fatty tissue (omental adhesion). At its free surface the granulation assumes a mushroom-like appearance. Intestinal epithelium extends over its lateral aspects, ending on each side in a single layer of cells.

EXPERIMENT DOG 198. Female, medium size. Operation, February 18, 1914. Incision in hypogastrium. Some free fluid in abdomen (the result of an abdominal operation performed three weeks before?). Large intestine about 10 centimeters from the anus delivered into wound, semisolid fæces massaged out, clamps applied. Circular section of the wall 2¼ x 2¼ centimeters removed, replaced by slightly larger sheet of fascia lata. Redundant mucosa not excised. A number of reinforcing Lembert sutures were required, comprising practically a second tier of sutures. Clamps removed, fascia bulged outward, no leakage. Layer suture of abdominal incision.

Postoperative course. Normal temperature on the second day, no subsequent abnormal manifestations. Stools as before operation. Animal sacrificed with chloroform because of beginning distemper on March 24, five weeks after operation.

Postmortem examination. Omentum broadly adherent to field of operation so that region of defect cannot be seen. No evidence of constriction of the lumen, as tested by water-pressure. With same test no sign of weakness of bowel at site of transplantation. After washing away fæces the appear-

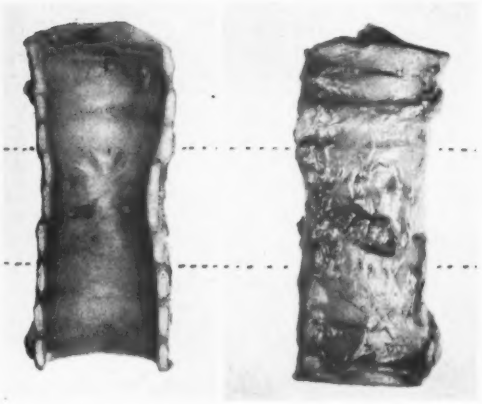

Fig. 39. Pathology No. 3840. External and internal views of trachea eight weeks after fascia transplant into defect involving two rings. Site of defect between the dotted lines. Hardened specimen, exaggerating distortion.

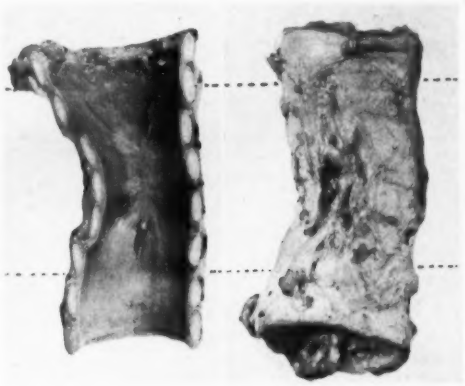

Fig. 40. Pathology No. 3841. External and internal views, eight weeks after fascia transplant into large tracheal defect involving three rings. Site of defect between the dotted lines. Hardened specimen, exaggerating distortion.

ance of the field defect was that of a somewhat depressed ulcer healed down to a very small area in the center.

Microscopic examination. Surgical Pathology No. 2932. The exact margins of the original defect cannot be determined, but there does not appear to be any great shrinkage in size. Granulation tissue fills the free surface of the defect and extends into a thick, closely-woven layer of connective tissue (scar tissue) situated opposite the mucularis and serosa. Bundles of muscle-fibers, principally from the inner muscular layer, extend across the position of the defect, fusing with the scar tissue. The surface of the granulation tissue is covered by intestinal epithelium in several layers toward the periphery of the defect, in a single layer almost completely over the middle. The omental adhesion is represented by a broad layer of fatty tissue rich in thick-walled blood-vessels.

6. FASCIA TRANSPLANTATION INTO TRACHEAL DEFECTS

The first experimental work in this field was performed by Hohmeier. He found that fascia could be successfully transplanted over very small tracheal defects (one-half to three-quarters of a square centimeter) and that flat epithelium grew in part over the granulation tissue occupying the surface of the defect. Davis, in replacing similarly small (8 x 8 millimeters) defects found that complete epithelial overgrowth (type of cells not mentioned) developed. Larger areas (less than 2 x 2 centimeters) were replaced by fascia in a series of experiments reported by Kostenko

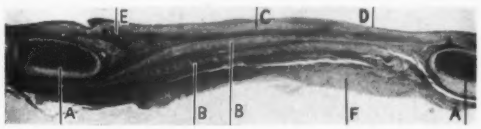

Fig. 41. Pathology No. 3841. Longitudinal section through trachea at site of transplant. *A*, *A*, Cross sections of cartilage rings at both sides of defect; *B*, *B*, the two layers of fascia lata; *C*, *F*, layers of connective tissue covering fascia; *D*, layer of epithelium; *E*, silk suture.

Fig. 42. Pathology No. 3841. Enlargement at *E* in Fig. 41. *A*, continuous layer of ciliated epithelium, the cilia very indistinctly shown; *B*, silk suture; intimate fusion of degenerating fascia, *C*, *C*, *C*, with connective tissue, *D*, around cartilage.

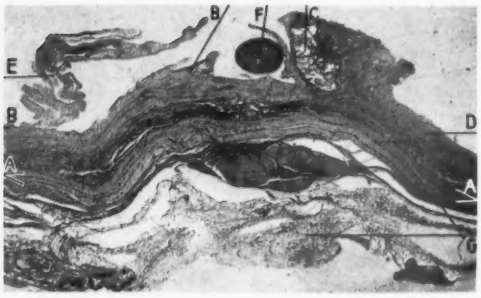

Fig. 43. Pathology No. 3153. Five months after fascia transplant into pleurothoracic defect. *A*, *A*, The two layers of altered fascia bridging defect; *B*, *B*, parietal pleura with layer of mesothelium spread over free surface of defect; *C*, lung adherent, chiefly by *D*, thickened pulmonary pleura; *E*, villous projection of regenerated pleura; *F*, artefact; *G*, subcutaneous tissues.

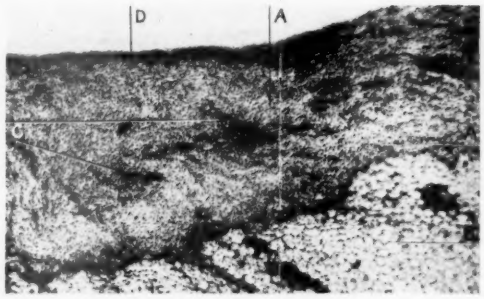

Fig. 44. Pathology No. 3047. Two weeks after fascia transplant over defect of lung. *A*, *A*, layer of altered fascia intimately adherent to lung, *B*; *C*, round-cell invasion; *D*, smooth free surface of transplant.

and Rubaschew; here, however, overgrowth of tracheal epithelium was never seen.

Fascia replacement of minute tracheal defects has little practical importance, since ordinary surgical methods accomplish this satisfactorily. If the work of Kostenko and Rubaschew is accepted, the replacement of somewhat larger defects by fascia is undesirable because the exposed granulating transplant would be apt to lead to complications. Clinically the cure of large defects of the trachea is as yet an incompletely solved problem. Complicated plastic operations have been devised in the effort to radically close these fistulæ. Flaps from the sternum or clavicle have been turned upward to supply the necessary rigid layer of tissue in the gap. For tracheal fistulæ at a high level, flaps from the thyroid or cricoid cartilages have been turned downward. The results that have been obtained by various methods will be detailed later; it will suffice to say here that failures have followed all the advocated procedures.

If experimental transplantation of fascia into large tracheal defects proved completely successful despite the difficulties that exist in the care of animals after such operations, it could be said that the application of this procedure to the human being offers the most logical method of treating such large tracheal defects. In the experiments to be described it was found that very large tracheal defects could be replaced satisfactorily by transplanting fascia *into* the defect. Very little stenosis followed. The ciliated tracheal epithelium grew completely over the transplant soon after operation. Both anatomically and functionally the results were well-nigh ideal. In my first experiment the transplant was sutured *over* the relatively small defect, after the method advocated by Hohmeier and others, and leakage and pretracheal suppuration followed. In all succeeding experiments larger defects were invariably successfully replaced, without any technical difficulty or postoperative complications, by fascia implantation *into* and not over them.

Experiment Dog 65. Female, medium size. Operation, December 14, 1915. Ether insufflation anæsthesia. Vertical incision over trachea, middle portion. Trachea exposed about five rings below cricoid by splitting the muscles. Anterior aspect isolated for a short distance. Quadrilateral section removed from front of tracheal tube measuring 1½ x 1½ centimeters. It involved removal of two rings. Fascia lata, slightly larger, sutured in place with usual technique except that the continuous suture took larger bites than usual in the tracheal wall, the stitches were somewhat closer together, and every third stitch was tied. Suture of pretracheal musculature and skin. Cotton, collodion dressing. No bandage.

Postoperative course. Uneventful. No subcutaneous emphysema. Primary union. Animal chloroformed February 8, 1916, eight weeks after operation.

Postmortem examination. Slight stenosis of trachea at site of operation. Small area of overlying muscle firmly adherent. The inner surface of the original defect is covered by a smooth shining layer of tissue continuous without line of demarcation

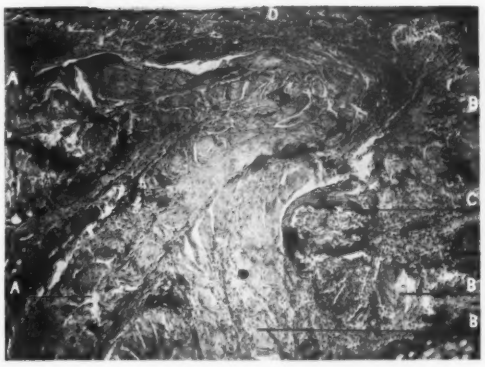

Fig. 45. Pathology No. 3048. Two weeks after fascia transplant into a pericardial defect. *A*, *A*, Folded end of degenerating transplant, firmly united to cut margin of pericardium, *B*, *B*, *B*; *C*, silk suture at site of junction; *D*, smooth layer of tissue on free surface of transplant.

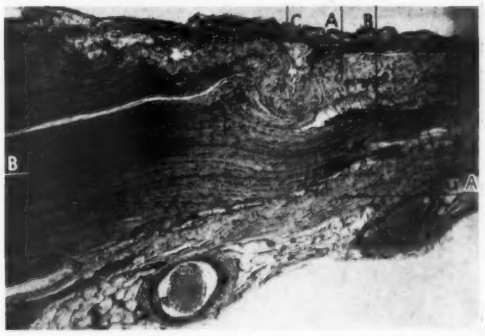

Fig. 47. Pathology No. 3206. Five months after fascia transplant into defect of diaphragm, showing the fusion between the altered transplant. *A*, *A*, and diaphragmatic musculature, *B*, *B*. In this section the continuous layer of pleura *C*, is well seen.

with the normal tracheal lining. The lines of silk sutures are seen shimmering through. By measurement between them very slight if any shrinkage can be determined. After specimen was hardened in formalin vertical section showed shining cut surface of fascia, covered on both sides by layers of tissue.

Microscopic examination. Surgical Pathology No. 3840. Characteristic structure of transplant remains, but there are evidences of hyaline degeneration throughout. Physical union between transplant and the pericartilaginous connective tissue is very intimate. The free surface of the transplant is completely covered by ciliated tracheal epithelium continuous with that beyond the site of the defect. A ridge in the epithelial layer represents the place at which overgrowth begins. The deep surface of the transplant is covered by a layer of thickly woven connective tissue. The cartilage rings at both sides of the defect are capped by masses of faintly staining, irregularly arranged cartilage-cells indicating budding or proliferation of the cartilage. These caps fuse with the ends of the transplanted fascia.

Experiment Dog 66. Medium sized male. Operation, December 15, 1915. Intratracheal anæsthesia. With same procedure as in previous experiment quadrilateral defect made in trachea included three rings in length and in diameter practically the entire anterior aspect of the organ. Defect measured 2½ x 2 centimeters. Fascia lata slightly larger, sutured in place as in previous experiment. To hold the transplant tense its margin was stitched to the adjoining surface of the overlying musculature in a few places. Layer suture of the wound.

Postoperative course. Uneventful. No subcutaneous emphysema. Animal sacrificed February 8, 1916, eight weeks after operation.

Postmortem examination. Slight stenosis of the trachea. No adhesions of overlying musculature. Silk sutures visible on external surface; by measurement between them slight shrinkage noted. Appearance of internal surface at site of defect identical with previous experiment — smooth shining layer of tissue continuous with tracheal mucosa.

Microscopic examination. Surgical Pathology No. 3841. The findings are practically identical with those in the previous specimen. The ends of the cartilage rings show active proliferation. Fusion between fascia and the tracheal tissues is complete, only the position of the silk sutures marking the

Fig. 46. Pathology No. 3206. Five months after fascia transplant into defect of diaphragm. *A*, Muscle of diaphragm at one margin of defect; *B*, *B*, layer of peritoneum (folded in the section) and *C*, layer of pleura spread over the free surfaces of the transplant.

Fig. 48. Pathology No. 3154. Six and one-half months after fascia transplant into a defect of the surface of the liver. *A*, *A*, Completely transformed fascia, recognizable as such in several places as at *B*. *C*, Surface of liver, smooth and intimately connected with the transplant. *D*, *D*, Islands of, and *E* individual liver-cells, scattered in connective tissue.

transition. Overgrowth of ciliated tracheal epithelium is complete. The characteristic appearance of the transplant is still moderately well preserved.

7. FASCIA TRANSPLANTS INTO PLEURAL DEFECTS

The first and most complete experimental work in this field was done by Kornew. He replaced pleural defects as large as 8 x 6 centimeters and found that, with little or no tension practically no changes in the structure of the transplanted fascia were observed, even after one year. It is to be noted, however, that, although the true fascial bundles remained unaltered, the interfascicular tissues did show distinct changes. This is significant, because it suggests ultimate conversion of the transplant into scar tissue. Kornew found a layer of flat mesothelial cells lining the pleural surface of the fascia. Adhesions between lung and transplant occurred very rarely.

The work of other experimenters need only be mentioned. All of Kirschner's experiments were failures, the animals dying of empyema. There were also many infections in Hirano's experiments, described in a very incomplete report. Adhesions between lung and pleura were encountered, but Hirano believed that these might have been avoided by inducing and maintaining a closed pneumothorax.

Fig. 49. Pathology No. 2747. Two months after fascia transplant into defect of spinal dura. *A*, Dura continuous with the thickened and greatly altered transplant; *B*, *C*, smooth free surface of transplant, mesothelial cells very indistinctly seen; *D*, silk suture at margin of defect; *E*, *E*, *E*, the spinal musculature, fused with the deep surface of the transplant.

Clinically, several cases of fascia transplantation into pleural defects have been reported. Payr's is perhaps the most interesting instance. After removal of a tumor of the chest-wall extensively involving the pleura, a large sheet of fascia was implanted into the defect. Upon examination six months later, a recurrence of the neoplasm was found, but the chest-wall was absolutely firm at the site of the transplant.

All previous experimenters considered it essential to suture the fascia transplant over the defect. The experiments I performed demonstrate that it can be satisfactorily implanted into the defect. In this situation two advantages are seen in the modification of technique. The ends of resected ribs are

not exposed intrapleurally, and friction between them and the transplant is eliminated. These advantages were evident to others (Hirano, Henschen), but fascial transplantation into pleural defects was not attempted, apparently because experimenters believed it would surely fail. Its desirability was especially appreciated by Hirano, who suggested that one sheet of fascia be fixed intrapleurally and a second sheet extrapleurally. In my experiments it was found that a single sheet of fascia, sutured into the defect, afforded permanently firm and air-tight closure. As will be seen from the following experiment, the additional observations at variance with Kornew's findings were: The transplanted fascia loses its characteristic structure relatively soon after operation. Pleural mesothelium grows over the defect, not with the normal arrangement of cells, but in an atypical form characterized by villus-like formations. Very firm adhesions occur between lung and transplant.

EXPERIMENT DOG 311. Male, small size. Operation, May 11, 1914. Intratracheal anæsthesia. Curved incision over lateral aspect of left chest. Flap of skin and subcutaneous tissues turned upward. Three ribs exposed near precordium, 5 centimeters of each resected. Underlying pleura removed, making a defect 4½ x 3 centimeters. Sheet of fascia lata, slightly larger, sutured in place; very slight tension. No air leakage. Wound closed in layers. Drainage tube placed in pleural cavity through a stab incision near the base of the thorax, stitched to the skin.[1]

Postoperative course. Uneventful. Drainage tube removed two days after operation. Animal chloroformed October 19, five months after operation. Thoracic wall at site of transplant remained firm and resistant, no suggestion of hernia.

Postmortem examination. Lung firmly adherent to a large part of the area in which fascia had been transplanted. When partly detached, it appeared as if pulmonary pleura alone was adherent. A thin layer of smooth shining tissue, continuous with the parietal pleura spread over the site of the defect, where the lung was not attached. Underneath it there was a firm thin layer of tissue, bright on cross-section, presumably the transplant.

Microscopic examination. Surgical Pathology No. 3153. The transplanted fascia has undergone some hyaline degeneration, stains very faintly and homogeneously in some places, contains many blood-vessels. It merges by insensible gradations with the adjoining connective tissue. Silk sutures mark the regions of transition. The free surface of the transplant is covered by a thin layer of connective tissue and this in turn by the pleural mesothelium. This is complete except where the lung is adherent. At several points the new pleural covering is heaped up into large villus masses attached by narrow pedicles. The lung is adherent to the transplant by a layer of dense connective tissue (pulmonary pleura).

[1] None of the operations involving wide opening of the pleural cavity were successful unless pleural drainage was instituted for a few days.

8. FASCIA TRANSPLANTATION INTO DEFECTS OF THE LUNG

The only studies made in this field were reported by Hirano. He employed fascia to cover wounds and to reinforce sutures of the lung, and concluded that bleeding, as well as leakage of air from the pulmonary tissues, were controlled by the transplant. Upon investigation one finds that Hirano's work is very incomplete (as he himself notes). Four experiments were performed, the period of postoperative observation varying from one to twelve days. In the latter instance he found that "the pulmonary pleura had grown over the transplant." Concerning the technique of operation, he advised that the fascia be sutured over the defect, the stitch-holes in the transplant not overlying those in the lung (to eliminate leakage of air), and that a slight pneumothorax be induced after operation in order to prevent adhesions to the transplanted fascia.

The experiments I performed demonstrate that fascia sutured *into* a defect of the lung guards amply against air leakage, and affords a firm resistant covering for the gap. Owing to the tendency to the development of empyema in dogs, the postoperative periods were not sufficiently prolonged to determine the ultimate fate of the fascia. In the limited time of observation, however, there was no evidence of an extension of the pulmonary pleura over the transplant. In one instance it was interesting to observe how firmly the fascia held in place despite the presence of an infection.

EXPERIMENT DOG 320. Male, medium size. Operation, May 13, 1914. Intratracheal anæsthesia incision in the left seventh intercostal space. Flat defect 1¾ x 1¾ centimeters made on the surface of the lung, replaced by same sized sheet of fascia held in place by interrupted sutures. Leakage of air

from one stitch opening. Stream of air-ether from intratracheal tube discontinued for a few seconds. Lung collapsed. Was permitted to expand slowly; no air-leakage followed. Drainage tube through stab wound at base of chest. Thoracic incision closed.

Postoperative course. Slight temperature. Drainage tube slipped out of pleural cavity 24 hours after operation. Animal appeared in good condition. Wound firmly healed. Death May 27, two weeks after operation.

Postmortem examination. Clear fluid in right pleural cavity, considerable turbid fluid in left cavity. Lungs collapsed, left of rather leathery consistency. Transplant firmly healed in place, could not be dislodged with maximum inflation of lung. Lung and fascia as well covered by a thin fibrinous exudate.

Microscopic examination. Surgical Pathology No. 3047. The lung contains a fair number of blood-vessels near the line of attachment of the transplant. This line is irregular and is made by a thin, dense layer of connective tissue containing many cells. The transplanted fascia is still recognizable as such, but in many places cannot be distinguished from ordinary connective tissue. It contains many round cells and very few polynuclear leucocytes. Its free surface is covered by a faintly staining layer of tissue containing few cells, a fair proportion of which are leucocytes. The union between fascia and lung appears absolutely complete.

No practical use of fascia as a covering for pulmonary defects has as yet been made. The results achieved in experimental work suggest that it may prove of value in operations for the closure of pulmonary fistulæ, or for friable, raw, or bleeding areas of lung encountered at operation. Although not concerned with the question of fascia implantation into lung defects, two suggestions upon the use of fascia in pulmonary surgery, made by Henschen on the basis of experimental studies, are of interest. One was to induce and maintain shrinkage of a lobe of the lung by ensheathing it with a sheet of fascia. The second was a method of air-tight capping of the bronchial stump with fascia.

9. TRANSPLANTATION OF FASCIA INTO PERICARDIAL DEFECTS

The problem of replacement of pericardial defects is encountered in clinical surgery only upon rare occasions. It is then of course essential to restore the continuity of the sac. Suture of the parietal pericardium being impossible or undesirable, plastic procedures are employed to fill the gap. I believed that fascia transplantation offered a much simpler, more rapid, and more efficacious means. This suggestion had already been made by Henschen; he did not, however, attempt to demonstrate its feasibility and it was not taken by up others.

The experiments I performed were not entirely satisfactory, owing to fatal pleural effusions that invariably developed. This well-known tendency to the development of pleural complications whenever the thorax of the dog is opened widely evidently had no relation to the operations on the pericardium.[1] Unfortunately, however, it made impossible the determination of the ultimate effects of the transplantation. The immediate results were excellent, anatomically and functionally, even when large defects were replaced. Firm union between fascia and parietal pericardium took place, despite the little nourishment accessible to the graft and the considerable tension upon it. The inner surface of the transplant became covered by a smooth layer of tissue, free from adhesions. The heart action might possibly have been interfered with in one experiment, that in which an infection in the pericardium resulted in a thin adhesion of the left auricle. These statements are illustrated in the following experiments:

Experiment Dog 325. Small male. Operation, May 18, 1914. Intratracheal anæsthesia. Pericardium exposed through an incision in the left fifth interspace. Circular section 4½ x 2 centimeters removed, phrenic nerve avoided. The defect enlarged rapidly by retraction of the pericardium. Owing to this, some difficulty in suturing sheet of fascia lata 5 x 2½ centimeters into the gap. Pleura drained by a tube inserted through stab wound near base of chest. Intercostal and pericostal suture. Incision in soft parts, and skin, sutured.

Postoperative course. Condition good for six days, then became poor. Dog chloroformed May 26, eight days after operaton.

Postmortem examination. Left lung collapsed, leathery. Considerable purulent fluid in pleura. Fascia firmly fixed in pericardial defect, covered by thin fibrinous exudate. Pericardial lining smooth. No adhesions to internal surface of transplant, which is smooth and bright. Small quanities of clear fluid in pericardial sac.

[1] In most of the experiments requiring wide pleural openings, reported in this paper, fatal pleural effusions developed despite intratracheal anæsthesia and the most careful asepsis.

Microscopic examination. Surgical Pathology No. 3048. The fascia has undergone some degeneration but still retains its typical structure. There is round-cell infiltration about the sutures that joined fascia to pericardium. A small mass of fibrin seals the chink between transplant and pericardium. The latter contains small areas of blood extravasation near the cut margin. The free surface of the transplant is smooth, and is occupied by a thin layer of homogeneous tissue containing few round cells. A similar layer of tissue is spread over the opposite surface of the fascia.

EXPERIMENT DOG 355. Large female. Operation, June 22, 1914. Incision in left fourth interspace. Pericardial defect 3 x 3 centimeters replaced by a slightly larger sheet of fascia. Suture of incision in thorax and drainage as in previous experiment.

Postmortem examination. Death ensued eight days after operation. Empyema. Lung collapsed, leathery. External surface of fascia transplant smooth, firm union between it and pericardium. Dry fibrinous exudate in pericardial sac. Thin soft adhesion between the tip of the left auricle and the middle of the transplant.

10. FASCIA TRANSPLANTATION INTO DEFECTS OF THE DIAPHRAGM

The first experimental efforts, made by Kirschner, were unsuccessful. In several experiments, carried out by Ikonnikoff and Smirnoff, diaphragmatic defects as large as 3 x 6 centimeters were satisfactorily replaced by fascia. Either omentum or liver was almost always found adherent to the transplant. The outcome of the operation was fatal in a number of instances, apparently because the experimenters approached the diaphragm through abdominal incisions and did not employ any method of inflation of the lungs. Henschen also succeeded in replacing large defects of the diaphragm by fascia. He invariably found the adjacent surface of the lung broadly adherent, and therefore considered this necessary for the provisional nourishment of the graft. Henschen and his predecessors believed that it was highly important to fix the fascial transplant over the defect, either on the thoracic or the abdominal surface, having it sufficiently large to permit generous overlapping at every point. Although histological examinations are not detailed, it appears evident that (1) the functional results were excellent with this technique; (2) adhesions interfered with a satisfactory anatomic result.

If fascia transplantation into diaphragmatic defects is to have any possible clinical application it is essential to demonstrate that the tissue in the gap offers a *lasting* barrier to the development of a diaphragmatic hernia or eventration. This had not as yet been done, and was the chief purpose of the following experiment. Although somewhat altered, histologically, after a period of five months, the large transplant was found firmly united to the diaphragm and sufficiently resistant to prevent any protrusion of the abdominal or thoracic contents. A unique feature was the complete overgrowth of the pleura on the one, and the peritoneum on the other, surface of the transplant, only a thin adhesion of the edge of the liver interfering with a perfect anatomical result.

EXPERIMENT DOG 350. Female, medium size. Operation, June 17, 1914. Intratracheal anæsthesia. Long incision in ninth intercostal space, left side. Moist packings isolated diaphragm from lung. Defect in diaphragm 5 x 4 centimeters, involving tendinous as well as muscular portion. Fascia lata of this size sutured in place. Drainage tube through a stab wound at base of pleural cavity. Pericostal and intercostal sutures. Soft parts and skin sutured in layers.

Postoperative course. Uneventful. Drainage tube removed in third day. Chloroform administered November 17, five months after operation.

Postmortem examination. Superior surface of diaphragm exposed by large incision in thorax. Slight adhesion between lung and diaphragm at site of drainage tube incision, but no adhesion to diaphragm in region of transplant. The latter was quite indistinguishable, except as outlined in part by the curved incision that had been made in the muscular portion. The entire upper surface of the diaphragm is smooth and glistening. Water distention of the abdominal cavity elevated the diaphragm as a whole, but did not result in any bulging at the site of the transplant. Except for a thin adhesion of the left border of the liver to the (presumable) situation of the transplant, the abdominal surface of the transplanted area was as smooth and bright as the other. Only when the specimen was removed and held to the light did the position of a number of sutures demonstrate clearly the general outline of the transplant.

Microscopic examination. Surgical Pathology No. 3206. The transplanted fascia shows some degenerative phenomena giving it a hyaline appearance. Its characteristic structure is apparent here and there in the long continuous sheet which

bridges the site of the defect. Many vessels of considerable size (carrying red blood-cells) are found in the fascia, especially near the margin of the defect. Layers of connective tissue overlie the surfaces of the altered fascia and, covering them completely, is a layer of pleura on one side and peritoneum on the other. These layers are continuous with the free surfaces of the normal pleura and peritoneum. Silk sutures mark the transition between the transplant and diaphragm; there is no evidence that either the transplant or the defect has contracted. The absolute union between the fascia and the muscle of the diaphragm is remarkably well demonstrated. Regeneration of the muscle across the defect has not taken place.

Despite the striking experimental results it seems probable that a clinical application of the procedure can be considered only in very rare instances. It has been demonstrated in a number of cases, that large wounds of the diaphragm can be sutured without any great difficulty (by mobilizing the thoracic attachment of the diaphragm, if necessary) and that defects can either be sutured or plugged by neighboring organs; stomach (Albert), liver (Friedrich, Anschuetz), spleen (Sprengel), lung (Borchardt). In other instances pedicled flaps from the thoracic or abdominal wall have been turned into the defect. Nevertheless fascia transplantation appears to offer a much simpler solution of the problem, and, in the future, it may be found desirable especially in the surgical treatment of diaphragmatic hernia or eventration.

II. FASCIA TRANSPLANTATION INTO DEFECTS OF THE LIVER

Excision of tumors and closure of wounds of the liver have been made possible by improved methods of suturing. It has been found, however, that, especially when the tissues are friable, the tendency for these sutures to cut through cannot be eliminated. The newer suture methods have been of little aid in the problem of obliterating large flat defects of the liver. In recent years efforts have been made to replace the tamponade treatment of bleeding raw areas of that organ by fixing living tissues in the defect. The object has been threefold: (1) to permit closure of the abdominal wound; (2) to eliminate the danger of secondary hæmorrhage after removal of the tampon; (3) to obtain the hæmostatic action of living tissue. Various tissues have been employed; fat, omentum, muscle, etc.[1]

It has been demonstrated that muscle transplants become necrotic at an early period. Adipose tissue does not offer good support for sutures and is bulky and irregular. Both experimentally and clinically, fascia has been found to answer best the purposes of any transplant in this field, chiefly because firm tension can be made upon sutures passed through it and the adjacent surface of the liver, and because it covers defects most smoothly.

Various methods of transplanting fascia into wounds of the liver have been described. The adoption of any one of them depends largely on the type of defect encountered. In deliberate excision of portions of the liver, as for tumor, some experimenters (Chessin, Kornew, and Schaak) find it most advisable to place the fascia strips upon the upper and lower surfaces of the liver about the area to be excised, using them as supports for the sutures passed through the substance of the organ. Absolute hæmostasis is obtained by tying these sutures. After removal of the desired section of liver tissue, the sutures are drawn together and the fascia strips are thereby approximated.

Very few clinical reports of fascia transplants into liver defects have been made. A most interesting case was described by Ritter. The patient sustained a rupture of the liver 6 centimeters long, the tear passing entirely through the anterior border. A strip of fascia 4 x 6 centimeters was placed upon the superior, and a similar strip upon the inferior, surface of the organ. Sutures were passed through both strips and the intervening liver tissue, and were drawn tight without evincing any tendency to cut through. The active bleeding ceased promptly; the patient made a smooth recovery. In Henschen's case a strip from the rectus sheath was satisfactorily employed as a simple covering for an incised wound of the liver.

The determination of the ultimate function of fascia transplants into liver defects is evidently of importance, yet this has not been

[1] Many surgeons have investigated this subject: Boljarski, Gluck, Jacquin, Koenig, Loewen, Loewy, McArthur, Senn, Springer, Stucky, Tuffier, Wrede.

even approximately estimated. One month has been the longest period of observation after transplantation (Davis). In this instance the small transplant (3 x 0.6 centimeters) was found viable, and adherent in large part to the underlying liver substance. The following experiment is therefore of interest because it demonstrates that, after a period of 6½ months, the transplant still remains intimately adherent to the original raw area in the liver, a very close fusion having occurred. Although largely disintegrated and replaced by cicatricial tissue, the purpose of the transplant was completely fulfilled. Well-stained liver-cells, individually and in small clusters, were found in the substance of the altered fascia.

EXPERIMENT DOG 252. Small male. Operation April 1, 1914. Incision in right hypochondrium. Liver external to the gall-bladder packed off. V-shaped section removed from the free border, measuring about 3 x 3 x 3 centimeters. Considerable oozing. Defect overspread by sheet of fascia 4 x 3 centimeters, folded so that it fit both the superior and inferior surfaces of the liver. It was held in place by a number of interrupted silk sutures. Oozing ceased. Layer suture of the abdominal incision.

Postoperative course. Uneventful. Animal chloroformed October 19, six and a half months after operation.

Postmortem examination. Thin omental adhesion to liver at site of operation and, apparently, to part of the transplant. Surface of the latter slightly rough, but fairly bright and glistening. Absolutely firm attachment of transplant to liver.

Microscopic examination. Surgical Pathology No. 3154. Omentum is adherent to one part of the free surface of the liver by a layer of connective tissue. To the remainder of the surface, the transplanted fascia is intimately adherent. Here also the attachment is by a layer of dense connective tissue. The free surface of the liver is smooth, its cells being adapted here to the surface of the transplant. Of the latter very little that is recognizable remains. For the most part it is transformed into a layer of loosely woven, faintly staining connective tissue. In some parts replacement by areolar tissue is evident. Scattered through the layer of altered fascia are well-stained small islands of liver-cells as well as isolated single or paired cells. The free surface of the transplant is in part smooth, but has a frayed appearance in many places.

12. FASCIA TRANSPLANTATION INTO DEFECTS OF THE SPINAL DURA

More than 80 cases of fascia transplantation into defects of the cerebral dura have been reported, with such uniformly satisfactory results that this application of fascia transplantation can be considered permanently established. Practically all surgeons now employ fascia lata in preference to all the other materials — fat, periosteum, peritoneum, etc.,— when the use of tissue transplants is decided upon. The ideal tissue to replace the dura is of course one possessing an identical structure, strong, and tendon-like consistency and at the same lined with mesothelium. There is, however, no such tissue that can be transplanted autoplastically in sufficient amounts. Fascia transplanted into dural defects in the human being has been examined after varying periods by von Saar, Chiari, Denk, and others. Adhesions between brain and fascia have been found, as well as areas of degeneration in the transplant (Denk's report has already been discussed). Therefore one may conclude that the fascia would be found ultimately converted into scar-like tissue. Functionally, however, the results in the reported cases were almost invariably good. In some instances (as in von Haberer's case) the transplant remained firmly fixed in place despite most unfavorable circumstances. There are a few cases in which the transplant was, with the exception of the skin, the only covering for the brain, and herniæ did not follow. Leakage of cerebrospinal fluid occurred in but two of all the reported cases.

The results of experimental fascia transplantation into defects of the cerebral dura accord with these clinical experiences, in a general way, except that leakage of cerebrospinal fluid has not been described. It is surprising to find that no experimental efforts have been made to determine the results of transplanting fascia into the spinal dura. If the experiments were satisfactory the clinical applicability of the procedure would be evident. The desirability of always closing the dura in operations on the spinal cord is now generally recognized. Conditions arise in which it is found impossible to suture the dura, or in which suture can be accomplished only by compression of the cord. The problem of closing the dura, under such circumstances, has not been solved. The following experi-

ment indicates that fascia can be transplanted into defects of the spinal dura even more satisfactorily than into defects of the cerebral dura, for adhesions to the underlying cord did not develop.

EXPERIMENT DOG 91. Male, medium size. Operation, November 1, 1913. Three spines and laminæ removed over lower dorsal region. Dura exposed. Quadrilateral section 3 x 1¼ centimeters removed. Operation on the underlying cord of no interest here. Sheet of fascia from over erector spinæ sutured into defect with usual technique. Layer suture of the wound.

Postoperative course. Uneventful. No leakage of cerebrospinal fluid. Death from distemper December 29, two months after operation.

Postmortem examination. Evidences of distemper in examination of respiratory tract. Wound firmly healed. Muscle intimately adherent to surface of transplant. Inner surface of transplant smooth and free, union between it and adjoining dura evidently complete. Cicatrix in cord, the result of the operation on it, lay directly underneath the transplanted fascia.

Microscopic examination. Surgical Pathology No. 2747. The characteristic structure of the transplanted fascia has largely disappeared, the tissue in the defect being a closely woven connective tissue that has undergone hyaline degeneration. In a few places flat cells are found on the thin homogeneous layer of tissue covering its free surface. A layer of striated muscle is intimately attached to its opposite surface. The fusion between transplant and the adjoining dural tissues is complete, silk strands being the only indication of the line of transition.

A CASE OF FASCIA TRANSPLANTATION INTO A CONGENITAL URETHRAL DEFECT

Large fistulæ of the urethra have been cured by operations consisting in mobilization of the urethra, with or without the addition of plastic flaps taken from the corpora cavernosa. However, failures have followed such procedures and incomplete successes (strictures of the urethra) have also been reported.

Leakage after suture of the urethra is a complication not infrequently observed, and the means taken to prevent it have not proved entirely adequate. The experimental reports of satisfactory reinforcement of suture lines in hollow viscera by fascia grafts, and the successful clinical experiences in the bladder (Koenig, Schmid, Kornew) naturally led to attempts to attach fascia strips over suture lines in the urethra. The results have not been very encouraging. Of four cases described in the literature, only one was an unqualified success. This was a male patient reported by Bachrach, in whom a urethral fistula persisted after incision of a postgonorrhœal abscess. The margin of the defect was freshened, the mucous membrane sutured, and a strip of fascia lata fixed over the suture line. The wound healed by primary union and the patient remained well and free from stricture at the site of operation. In two of the three remaining cases (Kleinschmidt, von Hacker), total failure followed fascia transplantation over urethral suture lines, the fascia becoming necrotic and ultimately expelled, and the fistula recurring in both instances. The fourth case (Hohmeier) may be termed an incomplete success. There was no leakage for eight days after an operation consisting in mobilization of a urethral fistula and suture of fascia over the defect. Upon attempted replacement of the permanent catheter that had been used, the tip of the instrument passed through the field of operation. Leakage of urine and discharge of small fragments of necrotic fascia followed. However, most of the transplant remained in place and the fistula ultimately closed.

At the outset it was stated that suture or plastic flap methods have cured large urethral fistulæ. Considering the discouraging results after transplanting fascia over urethral suture lines, was it justifiable to advocate the replacement of a urethral defect by a fascia transplant? With the experimental experiences, as well as the failures after suture and plastic methods in mind, I believed it fair to attempt this in the case to be reported. Very slight leakage occurred soon after operation and persisted for several days; however, the transplant remained in place and the patient is entirely well a year and a half after operation. It is realized that a single case is no absolute proof of the value of a method. On the other hand, a satisfactory result was obtained despite complications (leakage from one point in the suture line, and separation of the skin resulting in partial exposure of the transplant), and despite the

absence of any attempt to deflect the stream of urine from the field of operation by permanent catheter or suprapubic cystotomy. For these reasons it is hoped that the report of the following case will lead others to attempt the method.

Samuel C., 9 years old, admitted to the Har Moriah Hospital[1] November 26, 1914, with the history of leakage of urine from the under surface of the penis since birth. At the age of three, an operative attempt at cure of the condition failed (details not obtainable). The symptoms persisted as before. At night there is complete incontinence of urine. The patient has occasional good control during the day, but the mother finds him wet very frequently. When voiding voluntarily usually a large part of the urine (approximately one-half) escapes from the floor of the penis, the remainder from the tip. Sometimes most or all of the urine is discharged from the fistula. This happens rarely from the tip of the penis. There is almost always pain on urination.

General examination. The child is pale and poorly nourished. There are no other anomalies.

Local examination. On the under surface of the penis, a short distance behind the glans, there is a slightly depressed orifice about two millimeters in diameter, surrounded by cicatricial skin. The adjacent subcutaneous tissues are firmly infiltrated. A probe enters into the urethra without difficulty. The normal looking urinary meatus admits a good-sized sound that can be passed into the fistula at will, but must hug the dorsal surface to pass into the urethra beyond. Upon several occasions I had an opportunity to witness voluntary urination. Usually the fistula leaked urine in rapid drops at the beginning, the surrounding skin became greatly distended, urine then passed through the fistula in a continuous stream and, a little later, from the meatus in a small stream.

Operation, November 27, 1914. General anæsthesia. An elliptical section of the cicatricial skin about 2 x 1½ centimeters was excised with the short fistulous tract. The defect in the floor of the urethra was then found to involve practically all of its ventral aspect, measuring approximately 1½ centimeters in width and 2 centimeters in length. The edges were freshened. A section of fascia lata slightly larger in size and of the corresponding shape, was removed from the lower part of the thigh and placed in the defect. Its muscle surface was turned toward the lumen. Ten interrupted sutures of very fine cat-gut were passed from the transplant through all the layers of the urethra at the margin of the defect. As a result the fascia was firmly fixed in place, its margin slightly overlapping the margin of the urethral defect. The skin was freed and approximated over the transplant with slight tension. Dry dressing, wound in thigh sutured.

Postoperative course. The patient voided normally for three days. The dressing was then found to be damp and the wound was inspected. The lowest skin suture had separated, and a small area of the transplant was here exposed. Several drops of urine escaped with urination. This persisted for three days. Great care was observed at the necessary changing of dressings.[2] By the time the skin sutures were removed, eight days after operation, the wound was found firmly healed except at the lower angle, where a very small patch of fascia was exposed beneath the slightly separated skin. At that time only one or two drops of urine escaped. Two days later there was no escape of urine, although the skin had not healed over. Nor was there leakage at any subsequent period. The wound healed slowly at the lower angle, the transplant not being completely covered in until two weeks after operation. The patient was discharged entirely well on December 18, 1914, with complete voluntary control of urination.

At an examination about one month after operation, urination was normal, the wound was found firmly healed, a slight infiltration being palpable in the depths. This became more pronounced subsequently, so that at the end of six months a definite plaque was palpable in the scar. In view of the experimental experiences in fascia transplantation into vesical defects the possibility of bone formation in the transplant was considered. Roentgen ray examination[3] was negative, however. The plaque gradually diminished in size and firmness; at the present time (June, 1916) it is imperceptible.

Endoscopy was impossible in this young patient, so that the question of growth of the urethral mucous membrane over the transplant could not be settled. There was never any evidence of stenosis, as tested by sounds upon a number of occasions. When the meatus was shut off during urination the urethral canal was found normally distended at the site of operation. The urinary stream is normal and is projected normally. There has been no interference with erection as observed by the patient's mother upon several occasions. Nocturnal incontinence ceased promptly after operation and has not returned.

[1] Service of Dr. Henry Roth, to whom I am indebted for the privilege of operating upon and reporting this case.

[2] I wish to thank the house surgeon, Dr. Hallerman, for the careful attention he gave to this case.

[3] Kindly made by Dr. Edgar D. Oppenheimer.

A CASE OF FASCIA TRANSPLANTATION INTO A TRACHEAL DEFECT

Reference has already been made to the one instance in the human being of successful fascia transplantation into a hollow visceral defect — Levit's case of fascia transplantation into a defect of the trachea. He was led to employ this procedure by Hohmeier's

experimental studies and because of the disadvantages of the operations that have been employed for tracheal fistulæ.

A small tracheal fistula can be closed by cauterization of the orifice, a method in vogue for many years. Several procedures have been advocated recently[1] for the cure of larger defects. When the fistula is situated near the cricoid cartilage a favorite operation consists in turning down a flap made of the superficial layers of the thyroid cartilage and the adjacent skin, the latter turned inward. The flap is accurately sutured into the defect. Although successful in a number of instances, necrosis of the transplanted cartilage, recurrence of the fistula, and symptoms from protrusion into the trachea have been observed. Furthermore it is a complicated procedure, of limited application, and can result in necrosis of the thyroid cartilage.

Another procedure consists in the construction of an osteocutaneous flap from the sternum (or clavicle) or a similar periosteocutaneous one. The flap is turned upward and sutured into the defect. The scope of this operation is less limited than the former, but it is also less desirable. Recurrence of the fistula and complications in bone healing at the source of the flap have been noted.

To eliminate the disadvantages of flaps, a procedure requiring three stages has been employed. A section of rib cartilage is first implanted under the skin near the fistula. After it has healed in place, a flap of the transplant with overlying skin is fixed in the defect. At the third sitting the flap is detached and its divided pedicle sutured into the remaining part of the defect. Although satisfactory results have been reported, the disadvantages of this procedure are evident.

The drawbacks to these operations having been recognized, several surgeons have practiced circular resection of the trachea for the cure of tracheal defects. Some successful cases have been recorded. The operation, however, is a major procedure (with a possible mortality), depends upon accurate and firm union at every point in the suture line (which may not always obtain in the trachea), and is applicable chiefly to tracheal defects of large transverse diameter.

In one instance the implantation of a sheet of silver filigree has cured a tracheal fistula. This simple procedure may prove to be a solution of the problem, yet the insertion of a foreign body is not comparable with the implantation of living tissue, provided the latter serves the desired purpose. The desired purpose *was* served very simply by Levit, for he replaced the defect with a strong and resistant tissue (the object of the complicated plastic operations) which could ultimately be converted into an equally strong and resistant tissue, and over which the tracheal epithelium could grow without difficulty (a possibility not invited by the plastic procedures or by silver filigree). Levit's case is as follows:

> An anterior median tracheal fistula, a short distance from the cricoid cartilage, followed attempted suicide. Three separate efforts to close the fistula by plastic operations failed. Levit operated under local anæsthesia. He removed a section of fascia lata the size of a fifty cent piece (?) (*Silbergulden*) and placed it in saline solution. The margin of the tracheal defect was freshened and the fascia placed over it with the superficial surface facing the lumen. The size of the defect is not stated; the transplant overlapped it by several millimeters. The margin of the fascia was attached to the adjoining trachea by interrupted sutures (catgut?). Some leakage of air and flapping of the transplant were noted, and additional catgut sutures were placed, controlling both. The skin was undermined and sutured over the fascia.
>
> The wound healed by primary union. Cosmetically and functionally the result was excellent. By laryngoscopic examination the site of operation was represented by a flat white circular scar about 10 to 12 millimeters in diameter; the lumen of the trachea was slightly narrowed at this level. The patient was well when seen eight months after operation.

The case I have to report is similar in the findings at operation and in the postoperative course. The technique of operation was somewhat different, the fascia being transplanted into and not over the defect. In consideration of possible leakage with the development of subcutaneous emphysema, one angle of the wound was drained. The transplanted fascia healed in place without reaction, there was no evidence of tracheal stenosis, and the patient remained well.

[1] The literature is to be found in Levit's paper.

Pauline W., age 20, was admitted to the Har Moriah Hospital[1] August 9, 1915, requesting relief chiefly from the cosmetic deformity and difficulty in phonation.

Ten years ago a tracheotomy was performed (for laryngeal diphtheria?). The wound never closed. An attempt to heal it by cauterization failed. The patient coughed almost constantly, but did not complain as much of this as of the above-mentioned symptoms.

The general examination was negative. The voice was husky, made clearer by placing the finger over the fistula. The latter was situated in the midline in the lower part of the neck, at the level of the thyroid isthmus. The hiatus in the cicatricial skin measured approximately one centimeters. There was no evidence of stenosis above the fistula.

Operation, August 17, 1915. Local anæsthesia. The cicatricial tissue and skin about the tracheal opening were excised. The defect in the trachea was freshened and then found to be almost circular, measuring about 2 x 1¾ centimeters. A sheet of fascia lata slightly larger and of the same shape, was removed from the lower thigh and at once transferred into the defect. The muscle surface of the transplant faced the lumen of the trachea. The fascia was fixed to the tracheal wall by four fine catgut sutures, and a continuous suture was made between them (as described in the experimental part of this paper).

There was no leakage or flapping of the transplant with forced breathing. A small rubber-tissue drain was placed down to the transplant. The remainder of the wound was sutured after the skin had been mobilized.

Postoperative course. Uneventful. The drain was extruded on the third day and was not reinserted. Coughing was subdued but almost constant for the first few days, disappeared thereafter and did not return. The wound healed by primary union. In the first few weeks the field of operation bulged slightly with explosive coughing efforts. This ceased subsequently. Direct tracheoscopy was not permitted; by laryngoscopic examination the site of operation was indistinctly seen as a pale, flat, apparently smooth patch.

The patient has remained well (February 1916, six months after operation). Phonation is good, she is free from cough and from any symptoms referable to the transplant. The field of operation is flat, smooth and firm, no infiltration is to be felt.

The fact that the operation of fascia transplantation has been successful in two cases of good-sized tracheal fistulæ does not of course establish it as the one operation for the condition. That it is a much simpler, far less dangerous procedure than those previously employed cannot be questioned. In view of the experimental results that are reported elsewhere in this paper, and of the clinical results experienced by Levit and by myself, I feel no hesitation in urging that fascia transplantation be attempted for tracheal defects before any more complicated operations are essayed. With an experience of one case, it would be presumptuous to argue for the acceptance of my technique rather than Levit's. It may be said that some tracheal stenosis followed Levit's operation, and this was not evident in my case; however, the defect that was replaced appears to have been larger in his patient. It can, however, be definitely stated that, experimentally, fascia transplants have successfully replaced large tracheal defects when sutured into them and have failed to cure such defects when sutured over them.

[1] Service of Dr. A. V. Moschcowitz, to whom I am indebted for the privilege of operating upon and reporting this case.

Summary

The free transplantation of fascia into aseptic fields has a wide sphere of usefulness. It has proved very satisfactory in the replacement of thoracic defects, of aponeurotic defects in operations for various types of hernia, and of defects of the cranial dura. Fascia transplants have been very successfully used, in a variety of ways, for the reinforcement or replacement of ligaments, tendons, and paralyzed muscles. They have proved effective as coverings for wounds of solid organs, especially the liver. Their usefulness has not been clearly demonstrated in other aseptic fields; as sheaths for the isolation of nerves, as strips for occlusion of the pylorus, in fixation or suspension of organs, for separation of joint-surfaces.

There are many advantages of fascia over other tissue transplants (fat, muscle, periosteum, etc.) for the purposes mentioned. Fascia (lata) is most readily accessible, is obtainable in almost unlimited quantities, its removal does no damage. Transplanted fascia has a remarkable tendency to heal in place even under most disadvantageous conditions, requiring minimal nourishment to obviate necrosis. It combines great tensile strength with slight tendency to stretch or to contract. It is most readily adaptable to

the shape of any organ and, technically, can be most easily handled. Finally, fascia can be invariably transplanted autoplastically. The other transplantable tissues have some of these characteristics, none of them has all. The ultimate fate of transplanted fascia has not been definitely determined. The experiments I have reported indicate early disintegration in non-aseptic fields, degeneration at later periods in aseptic fields. Of practical importance is the fact that the resultant firm connective tissue is as serviceable as the original transplant.

These striking qualities led to attempts to employ fascia transplants in non-aseptic fields: in the presence of infection, or about hollow viscera. A few successes and about an equal number of failures followed. The use of fascia for such purposes was deemed undesirable, the successful results having been considered fortunate accidents.

Experimentally, fascia transplants have been found satisfactory for the reinforcement of suture-lines in hollow viscera. They were successfully employed in a few instances to bridge small tracheal fistulæ, and they occasionally prevented leakage from small œsophageal and bladder fistulæ. These occasional satisfactory results were found to depend upon healing by contraction of the defect. For this reason failure followed every experimental effort to replace appreciable œsophageal and vesical defects.

The technique employed in these experiments on hollow viscera (and on other organs) was the attachment of the transplant over the defect. To offer any chances for uniform success a method was evidently required to prevent the cut margin of the organ from rolling back, to give sutures a firmer hold on the organ by passing them through all its layers, to more readily supply the graft with provisional nourishment, and to invite the overgrowth of the lining mucous membrane of the organ. It is demonstrated in this paper that these requirements were met satisfactorily by suturing fascial sheets into instead of over defects of hollow viscera (and of other organs). With this technique I obtained the following results:

1. Large vesical defects (up to about one-half the bladder-wall) were replaced by fascia with uniform success. The functional and anatomic results were excellent. They were attained by the upbuilding of a new bladder-wall. Epithelial overgrowth at the site of the defect was complete at an early stage. The newly formed bladder-wall was as thick as or thicker than the remainder, and equally or more resistant to pressure from within. This was probably due in part to the fact that bone appeared invariably at the site of the defect, definitely limited to that area. The osseous tissues appeared remarkably soon after operation, reaching the height of their development in the second or third month. In conjunction with the bone there was formed typical bone-marrow (and cartilage, in one experiment) and an ensheathing, periosteum-like layer of connective tissue. That the transplanted fascia as such was not responsible for the formation of bone, was demonstrated by the development of osseous tissue when fat was used to bridge vesical defects. The formation of bone and related tissues was explained by the theory of connective-tissue metaplasia, the assumption being that calcium salts, derived from the urine, were the centers of stimulation.

Another uniform feature was the presence of smooth muscle in the connective tissue occupying the defect. It was continuous with the muscle of the bladder-wall. Its presence was accounted for on the basis of smooth muscle regeneration.

2. The immediate anatomic and functional results of replacement of extensive ureteral defects by tubes of fascia were satisfactory. Ultimate results could not be ascertained, for reasons that have been stated.

3. Large tracheal defects (involving as much as three cartilage rings and most of the anterior aspect of the organ) were invariably replaced successfully. The anatomic result was ideal, ciliated tracheal epithelium growing completely over the transplant soon after operation. The functional results were satisfactory, the newly formed tracheal wall being rigid and resistant, the narrowing of the tracheal lumen being insignificant.

4. Large œsophageal defects were replaced successfully in all experiments. Slight steno-

sis developed soon after transplantation; at later stages this was almost imperceptible. Epithelial overgrowth was complete. The functional was as good as the anatomic result.

5. Perforation through the transplant invariably followed its simple implantation into gastric defects. On the other hand, smooth healing always occurred, even with very large defects, when gastro-enterostomy, with or without pyloric exclusion, was added. This striking contrast demonstrates the profound influence of gastro-enterostomy upon healing of gastric lesions near the pylorus. Healing was firm and complete, gastric mucous membrane completely overgrowing the site of the defect. In one instance bone formation in the scar tissue was observed. Its development was explained on a basis similar to that suggested in the group of bladder experiments.

6. Fascia transplantation into small defects in the upper part of the small intestine was occasionally successful, succeeded more often in the lower part of the small intestine, was most successful in the large intestine. In the latter, larger defects could often be satisfactorily replaced. Healing took place by the upbuilding of new tissue and partial epithelial overgrowth, as well as by some contraction of the defect.

The following results were obtained in transplanting fascia into defects of organs other than the hollow viscera:

1. The (altered) transplant became firmly and permanently adherent to large defects made in the liver. Previous experiments had only demonstrated good immediate results, whereas, for stated reasons, the determination of the more distant outcome was considered of importance.

2. Large defects of the diaphragm were satisfactorily replaced by fascia. The (altered) transplant healed firmly in place, permanently preventing the development of hernia or eventration. Its surfaces were completely overgrown by parietal pleura and peritoneum respectively. Previous experiments had not demonstrated this mesothelial overgrowth. They dealt with immediate results, which were good functionally, indifferent anatomically.

3. Large pleural defects were satisfactorily replaced by fascia. The final results were good, anatomically and functionally. Overgrowth of pleural mesothelium was complete except where the lung was adherent. Adhesions were not encountered in some previously reported experiments.

4. Good immediate results were obtained in transplanting fascia over large defects of the lung. The firm union prevented leakage of air; the free surface of the transplant was smooth and non-adherent. Final results could not be ascertained, owing to the development of pleural effusions.

5. The immediate functional and anatomic results of transplanting fascia into large defects of the pericardium were good. Final results could not be ascertained, owing to the development of pleural effusions.

6. Large defects of the spinal dura were satisfactorily replaced by fascia. Adhesions between the incised underlying cord and the (altered) transplant did not develop. Previous experiments and operations dealt with defects of the cranial dura; adhesions between the transplant and the unoperated brain were encountered.

The clinical aspects are discussed in each of these groups of experiments. In addition, two clinical reports on fascia transplantation into defects of hollow viscera are appended. In one it is demonstrated for the first time that a large urethral defect can be very satisfactorily and very simply replaced by fascia. A similar demonstration is made in a large tracheal defect; this is the second case recorded in which fascia has been transplanted into a tracheal defect.

It is a pleasant duty to close with an expression of my indebtedness to Dr. William C. Clarke, Director of the Laboratory of Surgical Pathology, for many invaluable suggestions and constant co-operation in the progress of this work.

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[1] Many of these references have been investigated and verified, but responsibility cannot be assumed for the correctness of all. Most of them are derived from the publications by Kleinschmidt and by Kirschner. They are arranged, as far as possible, in groups according to the uses that have been made of fascia and other transplants.

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OPERATIVE IMMOBILIZATION OF THE SPINE[1]

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OPERATIVE immobilization of the spine has, as we know, been practised at least 20 years. However, the first attempts at immobilization were, for obvious reasons, unsuccessful; they were unable to meet the twofold requirements of rapid and permanent support. Chipault and Hadra, who proposed and applied wire sutures to the spinous processes or to the vertebral arches, certainly achieved rapid, but not permanent support, as the wire they employed gradually cut through the bone, and the latter was exposed to a certain amount of traction. The suggestions of Calot and Vulpius to employ flaps of periosteum obtained from the spinous processes might, if successful, have achieved permanent but by no means rapid support. The same remark applies to Hibbs' and Henle's methods of breaking and forming flaps with the spinous processes. The two above-mentioned conditions could only be fulfilled by introducing a strong, sufficiently long bone-graft. It is by no means essential that the transplanted bone should primarily heal into its surrounding tissues. Its foremost task is rather to provide, by means of its inflexibility, an immediate and firm support. In the same degree as this support fulfills the function demanded of it, will it undergo gradual organization, i.e., it will be replaced by new bone which adapts itself, both in regard to form and firmness, to the demands made on it. The surgeon must, by means of an operation, pave the way for a more rapid and certain attainment of that which Nature achieves gradually in many cases of Pott's disease and traumatic injuries of the spine.

That was the line of reasoning I followed in December, 1911, when, in a case of total dislocation between the fifth and sixth cervical vertebræ, I transplanted a spina scapulæ into, and thus immobilized the lower part of the cervical spine, in order to give it, nine months after the accident, the necessary support. A few weeks later I had, for the second time, the opportunity of performing the same operation in a similar case. The favorable result obtained in both cases surpassed my expectations, and gave me the idea of trying the osseous graft in cases of Pott's disease. Only then I learned that Albee had published analogous attempts a few months before my first operation, with the one difference that I employed the spina scapulæ, and Albee a strip of the tibia. We have since then repeatedly performed the operation in tuberculous cases, but, being much more skeptic than Albee, we have restricted our attempts to twelve cases. We desired first to make sure by means of animal experimentation what carrying power such an implanted bone-graft might possess, and in what manner its healing-in process takes place. With regard to carrying power no results of experiments have hitherto been published, and in the works of Henle, Vogel, Clairmont, Erlacher, and Vulpius on backbone osteoplasty there is hardly any mention of the subject. With regard to the healing-in process we have, among others, the standard works on the healing-in of bone-grafts from the institute of Marchand, but Albee's publications prove that as yet there is no unity of opinion on the subject.

Dr. Hoessly was entrusted with the carrying-out of our experiments, the results of which we here briefly give conjointly:

The nucleus of the osteoplastic operation is contained in the question: How great is the supporting power of a surgically implanted bone-graft at the end of the healing-in process? The reply this question receives

[1]Translated by Dr. H. Parrell.

Fig. 1. Roentgenogram of specimen of a moderately pronounced experimental kyphosis in a dog.

must decide whether operative immobilization of the spine be justified or not.

We can obtain this reply by means of the two following methods:

1. By observing whether in living animals the bone implanted is able to hinder the formation of an experimental kyphosis.

2. By applying weight direct to the prepared immobilized vertebral column and thus determining postmortem the supporting power of a bone-graft which has been implanted *intra vitam*.

To carry out the first mentioned experiment it is necessary to generate a kyphosis. Unfortunately, circumstances placed monkeys, the only upright animals, beyond our reach, so that we had to be content with experimenting on dogs. We found[1] that by means of transperitoneally removing vertebral particles it is also possible in the case of these animals to produce a kyphosis which, as regards its mechanical origin, in no way differs from the spondylitic and traumatic kyphosis of the human subject. We operated on a series of 5 dogs, and produced a decided gibbus with an angular bend in the spine of 10° to 30° (see Fig. 1). We will not here dwell on the manner in which the hump develops; we merely observe that it is not caused by the static weighting of the spine, but principally by reflectible muscular traction on the part of the abdominal muscles.

After these necessary preliminaries we proceeded with our real experiments. In five dogs we employed Albee's method, removing a slab of bone from the ulna and implanting it on the lumbar spinous processes. About 2 months later on the average, after bony union was achieved, we again operated on the same dogs and removed ventrally parts of the vertebral bodies from under the bone implant, thus producing a complete gap in the continuity of the vertebral bodies. Whereas, as above stated, the first series of dogs presented a distinct kyphosis, the second series did not show the least deviation from the normal direction of the spine. (Compare Figs. 2, a and b.) In each case, without exception, the bone-graft prevented the formation of a gibbus.

Fig. 2. A (above). Roentgenogram of the spine of a dog two months after osteoplastic operation.

B. The same spine two and one-half weeks after the removal of parts of the spinal bodies situated underneath the graft. No kyphosis formation. A and B have the same direction.

The next step of interest was to determine the supporting power of the bone-graft.

To determine this question those parts of the spine which, in accordance with the method above described, had been previously immobilized by means of osteoplasty were dissected and a piece of bone was then excised from the ventral side of the corresponding vertebral body. The whole specimen was then changed in the direction of the backbone axis and the weight gradually increased until a slight curving of the inlaid bone and an approachment between the

[1] Detailed records and reports of experiments have appeared in Dr. Hoessly's paper. "Die osteoplastische Versteifung der Wirbelseule bei Verletzungen und der Spondylitis tuberculosa." Beitr. z. klin. Chir., 1916, cii.

vertebral bodies was just apparent. The investigation of several specimens proved that a weight of from 30 to 40 kilograms was supported by the immobilized portion of the spine without the least sign of curving. The accompanying sketch illustrates the mode of procedure (Fig. 3).

The experiment will become more clear if the reader takes into consideration the physiology of the spine. The latter serves the human subject, in the first place, as a body support, and the supporting power of the dorsal and lumbar spine depends entirely on the uninterrupted continuity of the vertebræ. Therefore, if the vertebral bodies suffer only a slight defect, as for instance occurs in the case of traumata or caries, the spinal column must break down and cave in to the front or sideways, a process that has been fully described by Ménard.

The experiments just described prove that the implanted bone-graft is capable of preventing a collapse of the vertebral bodies. Thus it fulfills the mechanical demands made on it, at least to a degree exceeding our expectations.

The results of this animal experimentation induced us to make similar tests as to the supporting power of spontaneous bony growths between the spinous processes in human specimens of gibbus. Here also it proved that natural, dorsal ossification possesses no slight supporting power; it amounted in fact, in the specimens at our disposal, to as much as 30 kilograms. This spontaneous ossification about the spinous processes of the backbone which had already been commented on by Bracket, led Albee to follow Nature's course in undertaking the support-bringing operation. However, up to the present time we have been unable to form a correct estimate of the supporting power of this dorsal ankylosis. Even Ménard, with his extensive experience in the treatment of Pott's disease, maintains that it provides no support whatever. The reason that this natural dorsal ankylosis cannot prevent the curving-in of the backbone is easily explained. Its formation is too slow and too gradual, months and years being required for its completion. Meanwhile the slow ossification and gradual immobilization must be accompanied synchronically by, at first a gradual, later on by a more sharply pronounced, curving of the spine. The spontaneous deposits of osseous tissue are, therefore, too late to prevent a hump forming. We observed further that a considerably thicker and firmer bone-graft may be employed for the operation in the case of the human subject than in the case of dogs, and that the firmer graft will also afford greater support. (Graft from tibia, Albee; spina scapulæ, de Quervain; median border of scapula, Ombredanne; rib, Toblasek.)

We shall further remind the reader that Albee has also implanted bone-grafts into the spinous processes of dogs. He did not, however, destroy any of their vetebral bodies, so that the conditions for a kyphosis were lacking, and the bone inlay was in no way subjected to traction or pressure. The transplantation was, therefore, carried out on perfectly normal spines. It stands to reason that these animal experiments could not determine the carrying and supporting ability of the bone-graft, and therefore could not determine its therapeutic value for backbone osteoplasty in cases of static insufficiency. Albee's experiments could, indeed, serve no other purpose than to determine microscopically the condition of the transplanted bone. The following discussion will show how far our own preparations enabled us to agree with the investigations and conclusions of Albee.

MICROSCOPICAL INVESTIGATIONS OF AUTO-TRANSPLANTED BONE-GRAFTS

Albee says with regard to the fate of transplanted bone-grafts: "The exact knowledge of the histological rôle which the bone-graft plays is fortunately immaterial to its usefulness, whether it serves as an osteoconductive scaffold or as an active osteogenetic force." With this view we agree, as long as merely the surgeon's view of the matter is concerned. To him it can be immaterial whether the implanted bone-graft undergoes any changes, whether it is only an osteoconductive scaffold, or whether it remains an osteogenetic force, if only the "clinical

usefulness" our experiments prove is present. Our experiments have, however, led us to form other conclusions than Albee as to the fate of the implanted bone.

For the purpose of histological investigation, the transplanted bone-grafts were hardened in Mueller's formal solution, then decalcified and imbedded in celloidin. The sections were tinted with hæmatoxylin and eosin, some of them with Van Gieson. Series of sections from transplants which had remained in the animal two, four, and six weeks, others five to eight months, were minutely examined. Thus it was possible to judge the fate of the bone at various periods after transplantation under the most favorable conditions. The only possible way of deciding whether bone fragments live or die is, in fact, to make a thorough microscopical exam nation of them, and above a:l, of the osseous cells in all their details (Marchand). As all details will be found in the original paper of Dr. Hoessly, we shall give here only a brief summary of our results.

a. *The investigation of bone sections from fortnight-old transplantations presents the following:* Lower magnification reveals nothing special in the bone. The color of the latter is certainly somewhat pale, but normal, and both the bone-cells and tissue in the marrow-spaces and canals seem to have undergone no change. It appears, in fact, as if the transplanted bone would, as such, continue to live. Higher magnification (homogene immersion) proves, however, that such is not the case. We find the bone-cells in the median area of the transplant greatly changed. Some of them are shrunken, and in general they are quite pale, or show no color whatever. These conditions prevail in all parts of the transplant, whereas the bone-cells of its bed, i.e., of the spinous processes, are everywhere well preserved and present normal form and coloring. Only here and there, in the border zone of the bone-lamellæ, just where the latter adjoin the marrow-cavities and haversian tubes, are to be seen, in contrast to the light red original bone, some new bone-lamellæ of a darker, reddish-blue tinge which present, as their most prominent characteristic, well formed, normal, darkly

Fig. 3.

tinged bone-cells reposing in the cellules. (Fig. 4.) In the marrow-cavities and tubes there is now no longer any dead tissue, but everywhere numerous young blood-vessels, young connecting tissue richly supplied with cells, and, what is more important, the marrow-cavities are lined with a high layer of cubic osteoblasts (Figs. 4 and 5). The presence of these osteoblasts points to a rich endosteal proliferation. While, as before mentioned, here and there in the periphery of the bone beams, new bone-lamellæ originate. They proliferate toward the old bone and are at length separated from the latter by only an extremely fine, bluish boundary line (festoon formation of the bone-lamellæ, Marchand). (See Fig. 5, x.) Nowhere in the neighborhood are small celled inflammatory infiltrations or more decided necrotic foci to be found. In different spots we observe that high osteoblasts leave their cell community and wander into the newly formed bone-lamellæ, where they become characteristic bone-cellules. This eradication of the old bone by the new bone-lamellæ is apparent in every section, and presents only quantitative differences.

These histological discoveries which coincide with those of Radzimowsky, A. Barth, Fischoeder, Valan, Marchand, and Axhausen — some authors we mention as having devoted their attention to the question of bone-transplantation — permit of no other conclusion than that bone-transplants in the vicinity of the spinous processes which have

Fig. 4. Fourteen-day-old transplant, showing plainly the transformed bone-lamellæ on the edges of the bone beams with very well tinged bone-cells. The other parts of the bone beams are of a lighter color, some cells are already dead, the remainder all faintly colored and shrunken. High rows of osteoblasts lining the canals and marrow-cavities.

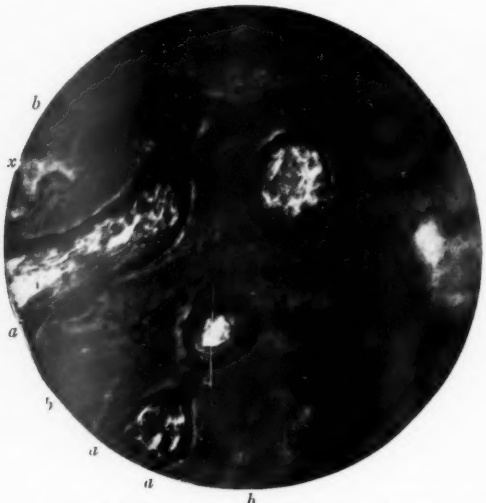

Fig. 5. Fourteen-day-old transplant showing distinctly the "festoon" formation of the bone-lamellæ in the old bone, *x*. In the latter old bone-cellules in all parts of the new bone-lamellæ, bone-cells in a state of good preservation. *a*, new bone; *b* old bone.

autoplastically healed in, are infallibly doomed, and that in the place of the old bone a new bone is generated by means of lamellary apposition. The originally transplanted bone is, therefore, from a histological point of view, doomed to death, and is replaced by a new bone. The new bone generates on the following lines: From out of the bed of the transplant, i.e., from out of the spinous processes, new blood-vessels proliferate and grow into the tubes of the original bone, osteoblasts immigrate, multiply, and gradually line the original bone cellules, and new bone-lamellæ form. Axhausen's and Saltykow's investigations prove without a doubt that the covering of periosteum contributes materially to the regeneration of the bone. The chief factors in this bone regeneration are, however, the bone-forming cells in the bed of the transplant. Even if in the fortnight-old transplant isolated instances of bony framework leave it open to doubt as to whether it has as such continued to exist, it does not in any way alter the fact that the transplanted bone, as a whole, dies in the neighborhood of the spinous processes, and is, as in the case of transplants in the region of the skull and extremities, replaced by new bone. Such parts of the bone as survive the grafting process and are able to live on, are found only in the cases of very young animals' bones, and in peripheral zones, where the conditions for their nourishment immediately after the transplantation are favorable. The central bony framework, however, that is to say, by far the greater part of the bone, dies in the manner above described, and new bone-lamellæ form in the place of the old ones. The fate of the bone salts has hitherto been a disputed question. Our investigations now permit us to assume that the salts of the original bone are mostly employed in building up the new product.

b. *A bone-graft investigated three weeks after transplantation* presents, on the whole, qualitatively, the same features as described under a. We have only to add that the old, dead bone has undergone further reduction and has been replaced by new bone-lamellæ. In several places the sections present completely transformed bone-lamellæ containing everywhere well preserved bone-cells. Further, we find in different parts of the periphery of the transplant lacunæ containing osteoclasts

which help to eradicate the old bone by means of erosion. A small number of these osteoclasts are also to be found in the fortnight-old transplant.

As regards the union of the bone-graft with the spinous processes: It consists in the fortnight-old specimen chiefly of fibrous connective tissue, and not until the transplant is older do we see, here and there, bone-lamellæ growing over from the spinous processes into the bone insert. In some spots they are very numerous and form coral-shaped branches. We must, however, mention that in between the new bone, cartilaginous islands are to be found. Their presence proves, what is easily to be understood, viz., that the union between the bone-graft and the spinous processes is not yet absolutely firm. In sections of older transplants this cartilage has disappeared.

c. *The examination of sections of bone-grafts four to eight weeks after transplantation* reveals no sign whatever of the original bone. All the bone-lamellæ have well preserved and good-tinged bone-cells. The fusion of the graft with the spinous processes is complete, and in the bone itself there is nothing to determine the line of union between the former and the latter. We have only to note that the structure of the new bone in the graft is more compact (more sclerotic) than in the original transplant, besides which we see at intervals spacious marrow-cavities which have originated in consequence of resorption. On the whole, however, the new-bone formation presents the same dimensions as the original bone, and, what is most important, the presence of rapidly increasing osteoblasts in the periphery of the graft, and the constant calcification of fibrous tissue shows that, even eight months after transplantation, ossification is still going on. With these facts as a basis, we assume that the graft increases in size, and that more especially when it is called upon to supply support. That is, of course, the function it is expected to fulfill in all cases of clinical transplantations in the region of the spine. A proof of the correctness of our assumption is shown in the case of R. W., the first operation of this description performed by de Quervain five years ago. The latest X-ray plate shows a distinct enlargement of the transplanted bone-plate.

Fig. 6. Spondylitic dislocation of the fifth cervical vertebra toward the front.
Fig. 7. The same case eight weeks after the operation.

It goes without saying that we have only employed such transplantation cases for histological investigations as have healed, without the least sign of infection, by primary union.

We have repeatedly accentuated how important it is, in forming an opinion of bone-transplantation, to carry out the most careful microscopical examinations, and to study the condition of the bone-cells. All other methods, such as the injection of blood-vessels and feeding with madder during the process of transplantation, do not enable us to form an opinion as to whether the transplant will live or die. Even the plentiful supply of blood-vessels in a transplanted bone-graft upon which Albee lays so much stress (profuse bleeding when the bone is incised) is not sufficient, as young blood-vessels can just as well proliferate into a freshly transplanted bone-slab as into mortified material (bone boiled or chemically prepared), or even into dead material (sponges). Only the periosteum and bone-cells can afford a sure criterion for the histological

condition of a transplanted bone-slab, in fact, for the biological condition of any tissue.[1] As far as we can judge from Albee's publications he prepared and investigated only such sections of bone-grafts as had been transplanted at least two months, and so he had not the opportunity of observing the important transformatory stages of the first weeks after transplantation. This will account for his assumption that the bone remains, as such, alive.

The fact that an autotransplanted bone-slab for the greater part dies and is replaced by new bone explains how it is that boiled, antiseptically prepared, macerated, even decalcinated bones can also be successfully employed as transplants. They can all, if the operation be performed under absolutely aseptic conditions, heal in by primary union, and all undergo transformation in the above-described manner. The advantage of employing fresh autoplastic material is, however, that the transformation of the original to the new bone is thereby facilitated, because the young blood-vessels and bone-forming cells can proliferate more easily into the old blood-vessel tubes, and the process of destruction and rebuilding up of bone substance is made easier (Marchand). For this reason I am inclined to believe that Albee's advice with regard to the excision and preparation of the bone-graft is of a too theoretical nature. Whether we chip out the bone-graft with a chisel, or with a specially constructed trephine, whether or not we incise the periosteum of the bone-graft in order to facilitate the process of osteoplastic proliferation, can certainly be of no importance if only the transplantation be attended by success.[2] Neither is it necessary to keep the bone graft in salt solution or in sterile vaseline. The paramount condition for a successful issue is a strictly aseptic and rapid operation. The chief aim to be borne in mind when immobilizing the backbone by means of osteoplasty is that observed by Albee and de Quervain. Both employ a solid and compact bone-slab which, from the beginning, insures thorough immobilization, and provides the spine with the essential support. All operative efforts hitherto made to promote ossification in the posterior region of the spine — the breaking and flapping over of spinous processes (Hibbs, Henle), employing strips of periosteum (Calot), or of small strips of bone periosteum (Vulpius) — are, as we already asserted in our introductory remarks, inadequate for a thoroughly firm fixation of the spinal region in question. All these operative methods are, at least in the months immediately succeeding the operation, simply unable to provide the spine with immobilization, so, as a matter of course, just these months are, in such cases, lost in the treatment, for instance immobilization of the spondylitic area against which the operation was performed.

Albee's opinion that the bone-graft possesses antibacterial force is entirely without foundation (the fundamental principles involved in the use of the bone-graft in surgery, and I must say that I myself cannot find a reason for this "bacteria resisting" quality. Neither do I think that Albee's theory will explain why accidentally infected bone-inserts should heal in without suppuration, and, as a fact, I have experienced several such cases in the course of my experiments. The graft can heal in, in spite of suppuration, in the same manner as infected bone fractures can heal.

Although we cannot declare ourselves as agreeing in every respect with Albee's theoretical views, seeing that our investigations have led us to form another opinion of the healing process, we do not wish to criticise the principle of osteoplastic immobilization that Albee first, and we shortly after, and independently, employed with success.

Having now, by means of Dr. Hoessly's investigations, obtained an exact conception of the mechanical abilities of the implant, we are able to give the clinical indications for its use more exactly than formerly, although many a question will be solved only by means of long-continued observation, and this is true especially in cases of tuberculosis of the spine.

As a result of our experiments and clinical

[1] Ztschr. f. orthop. Chir., xxxi, 463.
[2] Ztschr. f. orthop. Chir., xxxi, 465.

observation we are enabled to sum up the indications for osteoplastic immobilization of the spine somewhat as follows:

1. *Immobilization in the case of traumatic injuries to the spine.* We consider the operation justified in all cases of traumatic lesions in which the spine does not regain its normal supporting power, or causes pain when forced to carry weight, or finally collapses (the so-called Kummell's malady which our experience shows us is much rarer than literary statements would lead us to believe).

Permanent lack of spinal support is met with in cases of non-treated luxations, combined, as not rarely occurs in the region of the cervical spine, with an uninjured spinal cord. In such cases the patient is, with the exception of his luxation, well and competent to work. As long as a replacement of the dislocated parts is possible, we prefer it to immobilization. However, if the luxation is so old that an attempt at replacement would endanger the spinal cord, immobilization is more rational, and, according to our experience, more effective. It was on the latter indication that we undertook our first two operations in this direction. We made the observation that the motility of the neck was not, as might have been expected, decreased, but, on the contrary, increased, in consequence of the feeling of greater security the patient had in using the neighboring joints.

The indication is less reliable when movement is permanently attended by pain, or when the spine is called upon for support. There are spinal fractures, for instance, of the articulatory processes of the cervical spine which probably remain painful for a long time in consequence of traumatic arthritis, or of nerve contusion, and which lessen the competency for work. In such cases the surgical immobilization of the spine might be taken into consideration. We have operated only once for this condition and should like to accentuate that caution is necessary when dealing with neuropathic individuals, to be sure that the trouble is of mechanical origin. The third indication, viz., the subsequent breakdown of spinal bodies in the case of compression fractures is probably the rarest of all. We have not yet felt ourselves called upon to interfere in such cases, especially as experience shows that consolidation of the injured spinal bodies occurs in the course of time spontaneously, and in a very high degree. Still we should decide to operate if the angle formed by the spine above and below the injured area should become more pronounced some months after the accident, or if a gibbus should subsequently form.

2. *Osteoplastic immobilization of the spine in Pott's disease.* It was for the treatment of Pott's disease that Albee began using his method of immobilizing the spine. According to his reports the majority of his operations resulted favorably. The cases we have hitherto treated surgically permit us, when taking into consideration the relatively short time available for observation, to judge the operation favorably, yet we believe that the procedure is still in an early and experimental stage. In judging the successes hitherto attained, we must be the more skeptic, as we know that a great number of spondylitic cases heal without a noticeable gibbus occurring. Then again we must repeat that the operation does not effect a cure of the spondylitis, but simply provides better mechanical conditions for the healing process; we replace the orthopedic corset by a more reliable internal splint. A proof that the operation provides more favorable mechanical conditions is that in cases of Pott's disease, Nature herself endeavors to supply support by promoting a union of the spinous processes. Whether or not we eventually influence the healing process, and how extensive our influence may be, is a question that only years of clinical observation can decide.

The effect of the operation may so far be considered favorable, as it immobilizes in the highest degree possible the diseased vertebræ and permits the patient to maintain an upright position and to walk about earlier than would otherwise be the case. On the other hand we must ask ourselves whether cicatrization is not thereby delayed, seeing that juxtaposition of the still healthy parts of the diseased vertebral bodies is now

excluded. We dare not forget that the gibbus formation is in itself one stage of the healing process, as, after elimination of the diseased particles, the healthy parts meet and grow firmly together. The observation of a larger number of cases during several years will also serve to show in what way the process of cicatrization after operative immobilization of the spine takes place, and whether the newly provided mechanical conditions may not, for purely mechanical reasons, tend to delay its progress. We consider, at any rate for the present, that patients on whom the immobilizing operation has been performed should not be permitted to renounce the horizontal position until they are entirely free from pain. Let us start from the fact that osteoplastic immobilization of a tuberculous spine is not in itself a cure, but the best mechanical means of preventing a gibbus, and then try to deduce from this fact the indications for an operation.

The operation seems to us superfluous when pain caused by the weight of the body is not the prominent feature, and when an inclination to gibbus formation is not present.

It is optional, i.e., it offers the advantage of more rapid mobilization of the patient, when the inclination to gibbus formation and pain in consequence of bodily weight and pressure can be removed by an expedient form of recumbency (ventral recumbency).

It is to be desired in such cases as show a continued inclination to gibbus formation in spite of judicious recumbency. Of this Figure 6 is a good illustration. As a result of the destructive tuberculous process a dislocation had occurred between the fifth and sixth cervical vertebræ. It disappeared in consequence of a suitable recumbent position, but reappeared when the spine was again called upon to carry the patient's weight. The osteoplastic immobilization of the spine gave the result shown in Figure 7.

3. *Osteoplastic immobilization of the spine in non-tuberculous spondylitis.* There are, as we know, different kinds of deforming processes peculiar to vertebral bodies and vertebral articulations which have, perhaps somewhat prematurely, and without a sufficiently firm pathological — anatomical basis, been compiled into special classes (Bechterew and Pierre Marie), and which present pain on movement as their prominent feature. In these cases surgical osteoplastic immobilization might be given a trial, not with the idea of trying to attain a cure, but at least to try to remove, or, at least, mitigate the pain. We have not yet been called upon to perform the operation in any such case, but should like to propose its being taken into consideration should an opportunity occur.

THE EFFECT OF REMOVAL OF THE GALL-BLADDER

An Experimental Study

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IN 1887 Oddi (1), with the object of determining the functional importance of the gall-bladder, attempted to produce a continuous flow of bile into the intestine by completely removing the gall-bladder from dogs. This had previously been done by Zambeccari. The animals operated on recovered quickly and the sections made some time later showed the hepatic, cystic, and common bile-ducts dilated to twice or three times their normal caliber. The cystic duct seemed to be transformed into a reservoir for bile and had the appearance of a newly formed gall-bladder. To explain these results, it must be assumed that some powerful obstacle is opposed to the continuous outpour of bile and causes the marked dilatation observed in the bile-ducts. This led Oddi to the discovery of a special sphincter of plain muscle at the duodenal end of the common duct. He says that this sphincter is entirely independent of the muscular coat of the intestine. The idea that there was a sphincter muscle at the orifice of the common duct has prevailed since the time of Glisson, but Oddi was the first actually to describe this muscle. Oddi's material did not permit him to extend

Fig. 1. Photograph of the under surface of the liver of a normal dog. The biliary tract is fully dilated with air.

Fig. 2. Photograph of the under surface of the liver of a normal dog, approximately the same size and weight as shown in Fig. 1. The gall-bladder of this animal had been removed 214 days previously. Biliary tract also dilated with air. Marked dilatation of common and hepatic ducts.

Fig. 3. Photograph of under surface of liver of a dog 122 days after cholecystectomy. a, Stone in the common bile-duct. b, Small stone in the ampulla of Vater.

Fig. 4. Photograph of same specimen as shown in Fig. 3. The common duct has been opened exposing the stone.

his studies to the bile-ducts of man, but Hendrickson (2), in 1898, studied in detail the entire musculature of the extrahepatic biliary system. He found that there are many individual variations in structure but that these deviations do not alter the general anatomical bearing of this region. He concluded that a separate sphincter muscle exists at the duodenal end of the common duct in man as well as in dogs and rabbits.

Archibald (3) deserves great credit for calling attention to the action of this sphincter and the part that it may play in the etiology of pancreatitis. If pancreatitis is caused by the entrance of bile into the pancreas through the pancreatic duct, its presence in these ducts must be caused by obstruction offered by this sphincter at the duodenal orifice. Archibald found that the pressure in the common duct can be very greatly increased by stimulating the sphincter to contract. He suggests an operation for paralyzing the sphincter as a possible treatment for pancreatitis, and has performed this operation successfully in animals.

Our experiments show that the pressure in the common duct is greatly reduced and as a matter of fact may be almost nil sometime after the gall-bladder is removed. We believe this is due to the fact that after cholecystectomy the gradual increase in pressure first causes dilatation of the ducts and eventually overcomes the sphincter entirely. The bile then flows almost continuously into the duodenum and is not forced back into the pancreatic ducts. If this is true, it will explain what we feel sure is a clinical fact; namely, that cholecystectomy in many instances will cure pancreatitis.

Dogs, cats, and goats were used in our investigation. The latter were employed because of the relationship of the pancreatic duct to the common bile duct. The former enters the latter at a rather acute angle quite a distance from the duodenum. In the dog and cat, one of the pancreatic ducts opens into the common duct near the ampulla. All operative procedures were undertaken with the animal under anæsthesia and the usual surgical technique was employed. At different times after operation, except when death resulted from intercurrent disease, the animals were killed under anæsthesia and the points of interest carefully examined grossly, and in many instances, microscopically.

After removal of the gall-bladder, all the extrahepatic ducts dilate. This could be demonstrated in dogs and cats and to a less extent in goats. The dilatation varies from a very slight degree to twice or three times the

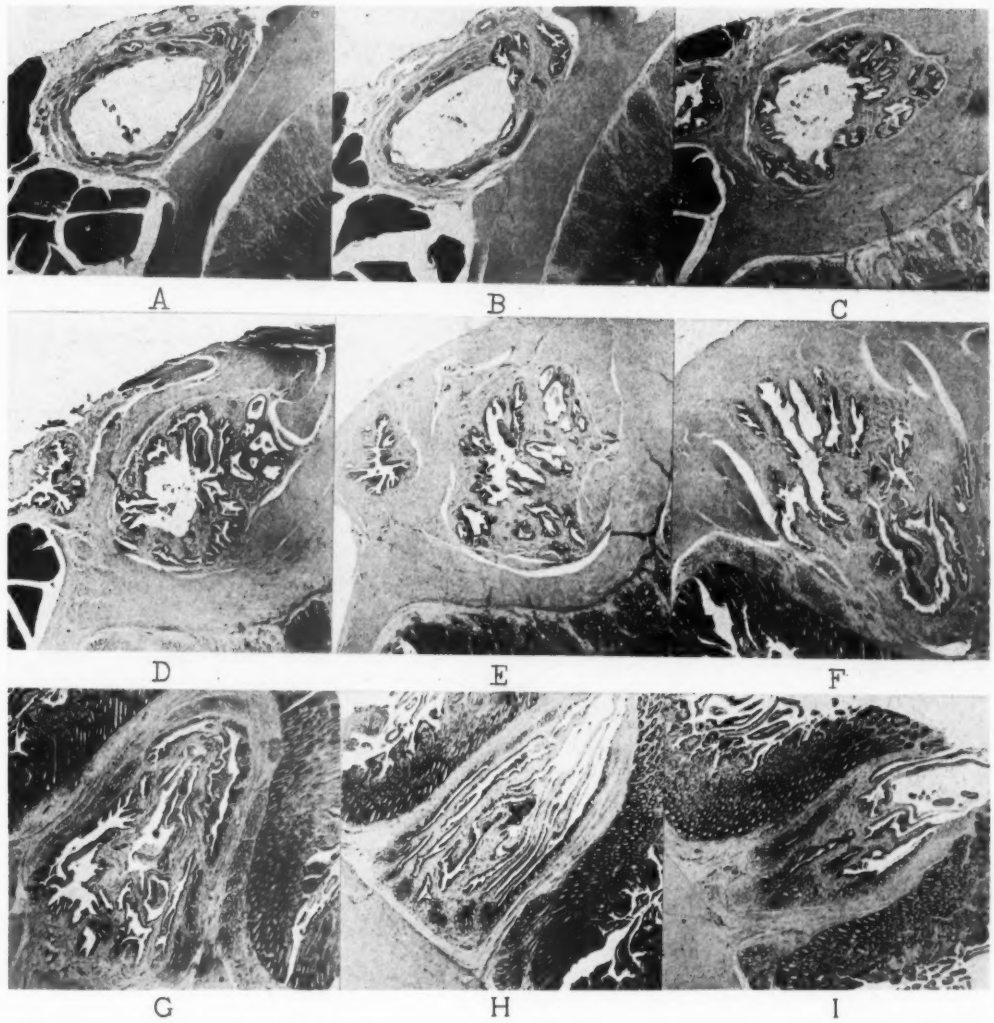

Fig. 5 (above). Photomicrographs of cross sections of the different parts of the common bile-duct of a cat showing the course of the duct through the duodenal wall. *A*, Duct immediately preceding its entrance into the muscle layer. *B*, Duct as it is beginning to pass through the muscularis. *C*, Duct at a point one-third of the distance through the muscularis. Pancreatic duct is parallel to common duct. X8.

Fig. 6. Photomicrographs showing the same duct as Fig. 5, in its passage through the muscle-wall. *D*, Common bile-duct and pancreatic duct parallel to each other, with the former in the center of the muscularis. *E*, Ducts still parallel; the common bile-duct almost on the mucosal side of the muscularis. *F*, Ducts about to unite, passing through the muscularis. X8.

Fig. 7. Photomicrograph showing the same duct as Figs. 5 and 6 on its passage through the mucosa. *G*, Common duct has just passed through the muscularis; the muscle is still broken. *H*, Duct has apparently entered the mucosa; the muscularis mucosa well defined. *I*, Opening of the duct into the duodenum.

normal diameter of the ducts. However, no dilatation was observed in the ducts within the liver substance; and the intramural portion of the common bile-duct is dilated to a less extent than the rest of the duct. The greatest dilatation of the biliary tract occurs at the

Fig. 8. Photomicrograph showing the bile-duct and pancreatic duct in the muscle wall. X24.

Fig. 9. Photomicrograph of the common duct just entering the mucosa, showing the intimate relation of muscularis mucosæ to duct. X24.

juncture of the hepatic ducts coming from the upper lobes of the liver. The cystic duct was found to be dilated in a few instances. That this condition was not noted more often, we attribute to the fact that usually when a cholecystectomy is done, the cystic duct is ligated very close to its juncture with the hepatic duct (in dogs and cats the true common duct is formed below the entrance of the cystic duct). In general, dilatation of the biliary tract occurred within 60 days after the removal of the gall-bladder of any dog or cat; but the time necessary for this change to be accomplished was variable. No changes were ever observed in the liver or pancreas, and even in goats the pancreatic ducts always appeared normal. The following experiment is typical:

Experiment 469. October 19, 1915. A male dog, weighing 10.2 kilograms. The animal was etherized and the gall-bladder removed. The diameter of the common duct at the time of operation was 6 millimeters. The animal was killed with ether February 9, 1916. The operative field was in good condition. The common bile-duct was dilated, having a diameter of 1 centimeter; after entering the wall of the duodenum, its diameter was only 6 millimeters. The cystic duct had been completely ligated at the time of operation. All of the hepatic ducts outside of the liver were dilated. The pancreatic duct seemed to be of normal size. The pancreas and liver were normal grossly and microscopically.

It is desirable to know the exact mechanism by means of which this dilatation is produced. As the increase in the size of the duct took place throughout its entire course, it is evident that the cause of the temporary obstruction and resulting dilatation must be located at its distal end. The most probable cause for this obstruction is the sphincter Oddi. The part this sphincter plays in producing dilatation of the biliary tract after cholecystectomy, we have investigated by three methods: (1) by comparing the pressure

Fig. 10. Photomicrograph of one of the bile-ducts of a dog, showing a cross section of an ascaris in the duct. X10.

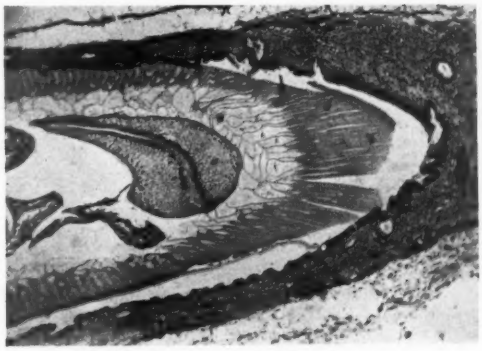

Fig. 11. Photomicrograph showing the biliary epithelium and the ascaris more in detail. X20.

withstood by the sphincter in normal and control animals; (2) by surgically dissecting the duct free from muscle fibers in its passage through the duodenal wall at the time the gall-bladder was removed; and (3) by sectioning the mucosal opening and a portion of the sphincter through a duodenal incision. The residual pressure of the common duct as measured by a water manometer (which is practically a measure of the pressure which the sphincter Oddi will withstand) is quite variable in normal anæsthetized dogs and cats. Deep etherization and long periods of anæsthesia together with the exposure and trauma of handling seem to decrease the tone of the sphincter and likewise the residual pressure. However, it is safe to say that in the normal animal under light anæsthesia of short duration, the residual pressure is always greater than 100 millimeters water and usually greater than 150 millimeters. These figures are much smaller than those given by Oddi and by Archibald. After removal of the gall-bladder the residual pressure is always very low; in some cases it was zero, and rarely was it greater than 40 millimeters water. The following experiment is representative:

Experiment 124. March 6, 1916. A black, female cat, weighing 2.3 kilograms, was etherized and its gall-bladder removed. The animal remained in good health after operation. August 2, 1916, it was again etherized and the water manometer was connected to the common bile-duct. A normal cat of approximately the same size (weight 2.2 kilograms), was also etherized and the common bile-duct attached to the same manometer through a two-way stop cock. The sphincter of the cat operated on withstood a pressure varying between 30 and 60 millimeters water, while that of the control animal withstood a pressure of 160 to 170 millimeters water. The common bile-duct of the cat operated on was dilated, having a diameter of 3 millimeters. The diameter of the common bile-duct of the control cat measured 1.5 millimeters. The liver and pancreas of each animal were normal.

In those animals in which the muscle fibers were dissected free from the intramural portion of the duct at the time the gall-bladder was removed, dilatation of the duct did not occur except when there was mechanical obstruction due to adhesions. The residual pressure in the unobstructed cases was always very low. The following experiment illustrates this point:

Experiment 176. March 24, 1916. A dog, male mastiff, weighing 27.9 kilograms. The gall-bladder was removed and the common duct dissected free from muscle fibers in its intramural portion. The operation was accomplished with difficulty — in one place the bile-duct was accidently opened but was immediately closed with one silk suture. The animal was quite sick immediately after operation, refused food and lost weight, but soon regained normal condition. July 18, 1916, it was etherized and the residual pressure estimated. The pressure varied between 20 millimeters and 30 millimeters water. There were many adhesions at the site of operation but the duct was not obstructed. The ligature on the cystic duct had cut through into the lumen and many small pin-point concretions were attached to it. There appeared to be a slight dilatation of the duct where the upper hepatic ducts joined. The common duct measured 7 millimeters in diameter and evidently was not dilated. The liver and pancreas were grossly normal.

Section of the mucosal opening and a por-

tion of the sphincter through a duodenal incision after removal of the gall-bladder has given variable results in regard to the effect on the duct, and positive conclusions cannot be drawn. However, in one perfect experiment the same dilatation occurred as in animals in which the gall-bladder had been removed:

Experiment 249. April 27, 1916. Cat, male maltese, weighing 3.1 kilograms, was etherized and its gall-bladder removed. The duodenal mucosa was cut at the opening of the common bile-duct through a duodenal incision. The animal remained in good health except for mange. July 7, 1916, the animal was etherized. The residual pressure in the common bile-duct was estimated and found to vary between 40 and 50 millimeters water. The common bile-duct was dilated and measured 4.5 millimeters in diameter. The hepatic ducts were also dilated. The pancreas and liver were grossly normal. The duodenal opening of the bile-duct was very patulous, measuring 4.5 millimeters in diameter. Both incisions were healed.

Section of the mucosal opening of the common bile-duct is not without danger, as the following experiment illustrates:

Experiment 104. February 21, 1916. Dog, female spaniel, weighing 13.2 kilograms, was etherized and its gall-bladder removed and sphincter of Oddi sectioned through a duodenal incision. The animal remained in good health except for slight mange. August 4, 1916, the animal was etherized and the common duct connected to a water manometer. The residual pressure was 100 to 120 millimeters water. There were many firm adhesions at the site of the operation but none of them in any way obstructed the bile-duct. The duodenal incision was well healed. The pancreas and its ducts were normal. The common bile-duct was certainly not dilated — it measured 2.5 millimeters in diameter. The duodenal opening of this duct was very patulous, its diameter being 5 millimeters. The incision had healed perfectly. The liver appeared grossly normal. On opening the bile-duct, it was noted that the remaining portion of the cystic duct was slightly dilated and contained an ascaris. One or more ascarides were found in the hepatic ducts. In the duct going to the upper right lobe there were three. The left lobe did not contain any. In some cases the ascarides were found deep in the liver substance.

The dilatation of the common duct which takes place after cholecystectomy does not prevent the guarding of the duodenal opening by the fold of mucous membrane; this fold continues to prevent reflux of material from the duodenum into the duct. In specimens in which the duct was greatly dilated and the residual pressure very low, it was impossible to produce a passage of fluid from the duodenum into the duct even though the intraduodenal pressure was increased enormously.

The following would seem to be the probable explanation of these facts: Normally, the liver secretes bile constantly, although the rate varies. However, because of the action of the sphincter Oddi, bile is not passed into the intestine at the same rate as it is secreted; the excess accumulates in the gall-bladder. After cholecystectomy, the sphincter attempts to maintain this difference between rate of secretion and rate of discharge, with the result that bile accumulates in the biliary tract. As the sphincter is able to withstand a pressure varying from 100 to 645 millimeters water and the secretory pressure of the liver varies from 230 to 360 millimeters water (4), the intraduct pressure can be considerably increased. This increased intraduct pressure produces dilatation of all extrahepatic ducts. The intrahepatic ducts are supported by the liver-tissue so they do not dilate. This process producing dilatation of the ducts is maintained until the biliary tract will contain as much bile as the gall-bladder, or, more often, until the sphincter itself becomes dilated and is not able to withstand its normal pressure.

SUMMARY

After removal of the gall-bladder, all of the ducts outside the liver dilate. The sphincter at the entrance of the common bile-duct into the duodenum is the chief factor in producing this dilatation. After cholecystectomy, this sphincter can withstand only a small percentage of the pressure which it normally maintains. When all the muscle fibers are dissected free from the intramural portion of the duct, the biliary tract does not dilate after the removal of the gall-bladder.

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THE SIMULATION OF CORPUS LUTEUM AND RETENTION CYSTS OF THE OVARY WITH ECTOPIC PREGNANCY AND EARLY UTERINE ABORTION

A Clinical and Pathological Study

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INTRODUCTION

CLINICAL observation has for some time led to the belief that delayed and irregular menstruation is associated with diseased adnexa. The reason for this belief has been based on the assumption that ovarian function determines menstruation. This phenomenon must therefore be disturbed by conditions that affect the ovaries. Without identifying the particular element or elements in the ovarian structure that were diseased it was recognized that gonorrhœal and tubercular suppurations and bilateral tumors involving the greater part or the whole of both ovaries were frequently responsible for the disturbed menstrual cycle.

That menstruation may be delayed by corpus luteum cysts and single retention cysts of the ovary is an observation of comparatively recent date and with the exception of one report by Halban[1] there has so far been no contribution to this subject. Both the subjective symptoms and the objective findings in such cases simulate an ectopic pregnancy so closely that it is often impossible except by laparotomy to differentiate between ectopic pregnancy and such cysts. They belong to the not infrequent group of cases commonly called *suspected ectopic pregnancy*. Besides this simulation clinically the more theoretical question of perverted physiology of the ovary and the uterus in relation to cause and effect is also one which necessarily concerns us here.

These retention cysts either primarily disturb the periodicity of the menses, affecting their course, amount, etc., appearing even to influence the change in size and consistence of the uterus, or they follow disturbed or augmented uterine function, chiefly those that obtain when the growth of a fecundated ovum is arrested at a very early stage. In either event, clinically, there is bleeding after a delay in menstruation, there is slight enlargement of the uterus and there is a mass lateral to the uterus — the classical signs and symptoms of an early tubal pregnancy.

The object of this paper is not only to call attention to this clinical syndrome but also to present data which may help to elucidate the question involved. As the corpus luteum is of great importance in this connection a brief discussion of its physiology and histology in the light of recent research will also be included.[2]

CLINICAL OBSERVATIONS

The cases that have come to my observation may be divided into three groups.

Group I. Delayed menstruation; hydrosalpinx, cystic ovary and enlargement of the uterus, simulating ectopic pregnancy.

Some six years ago a patient came to the Mount Sinai Hospital Dispensary Clinic complaining of pain in the right side of the pelvis. Her period had been delayed ten days, bleeding then began in an irregular way and continued for the next three days when she came for relief. The uterus was found slightly enlarged and moderately soft. On its right side was a soft elongated cystic tumor freely movable but very tender. The diagnosis of extra-uterine pregnancy was made with a great degree of certainty. All other conditions seemed unlikely. On opening the abdomen a hydrosalpinx and what was then called a cystic ovary increasing by three times the normal size of an ovary was found.

No curettage was done at the time but careful observation failed to note the escape of a decidual cast or a uterine mole. With the subsequent events in this case the writer is unfortunately not familiar.

This experience made a profound impression on me. From then on not only my diagnosis of

[1] The writer is gratified to find in Halban's report on the "Symptomatology of Corpus Luteum Cysts" corroboration of his own clinical observations. J. Halban. Zentralbl. f. Gynaek., 1915, xxxix, 409.

[2] For a full detail of the experiments that have served to build up our knowledge of the physiology of the corpus luteum, reference may be made to the admirable monograph of Fraenkel's in Liepmann's Handbuch der Frauenheilkunde, Vol. iii, 1914, and in R. T. Frank's comprehensive paper on the "functions of the ovary," Surg., Gynec. and Obst., 1911, xiii, 36.

ectopic pregnancy in this type of case became very much guarded but I began also to wonder why the menstrual period in that patient had been delayed. For future reference I noted that the physical signs of a moderate sized hydrosalpinx with an enlarged soft cystic ovary could clinically simulate an ectopic pregnancy. This experience was encountered a number of times since then.

Group II. Rupture of lutein cysts during examination and simulating accidental rupture of an ectopic sac.

On several occasions in patients with similar clinical history and the finding strongly suggestive of an extra-uterine pregnancy, I was almost terrified at the sudden disappearance under the grasp of my fingers of a cystic tumor in the pelvis giving a sensation that was most unmistakable. In each instance I feared there was a rupture of a gestation sac and anxiously awaited the reaction upon the patient, noting the pulse and watching the facies for increasing pallor. While in three instances the patients complained of a sudden feeling of peculiar discomfort akin almost to pain, the anticipated collapse did not set in and I was relieved to see them rise from the examining table, dress, and after some hours of observation at the clinic or reception ward of the hospital go home and report on the next visiting day. The physical findings were in each case confirmed by several associates. On several occasions also during the examination by one of them a soft cystic tumor broke. Later examination failed in all but one of these patients to reveal this tumor. In one case after several months there was a return of a cystic mass. In one other patient under observation at the Beth Israel Hospital in whom this occurred the impression of ectopic pregnancy ruptured by vaginal examination was so strong that an exploratory laparotomy was resorted to in the interest of safety. There was a moderate amount of slightly sanguinous fluid in the pelvis and a collapsed cystic ovary was found. The histological examination showed that this cyst was lined by a well marked border of lutein cells.

From a fairly large number of instances of suspected and positive ectopic pregnancy seen clinically during the past ten years there is no condition that in my opinion so closely simulates ectopic pregnancy as the condition just described.

Group III. Enlargement of uterus, delayed menstrual bleeding. Adnexal enlargement; ectopic pregnancy strongly suspected.

While these observations were being made, there came to my notice another group of cases with the clinical history of amenorrhœa of 6 to 8 weeks' duration with the physical findings not unlike that of a very early intrauterine pregnancy, complicated, however, by the additional finding of a mass on either side suggestive of an enlarged or cystic ovary. In view of the physical findings, ectopic pregnancy still unruptured is very seriously considered. This occurrence has been noted in several patients who desired children. Sometimes the uterus becomes palpably larger and softer before the bleeding takes place and it even seems as though pregnancy were normally progressing. When bleeding does set in it is apt to be scanty and irregular, and one is puzzled as to the actual condition. One is surprised in such instances not to see any specially large fragments, or membranes, or anything suggestive of fœtal structure escape from the vagina. Occasionally, as in Case R. R., a membrane is passed. Examination at such time reveals the uterus reduced in size, it is firmer in consistence and at the same time the mass on either side is smaller or has disappeared. The chagrin of the physician who has diagnosed pregnancy and the disappointment of the "expectant" mother can be readily imagined. The patients then stop bleeding, consider the diagnosis mistaken and regard the whole matter as a case of delayed menstruation. This may or may not be repeated at some future time. Not infrequently, however, this termination occurs in women who are rather anxious lest they continue pregnant. They are naturally less interested in the academic question of clinical interpretation and are relieved to see the delayed menses finally set in. It is not uncommon to meet this clinical syndrome in a woman who confesses to having submitted to an attempt at induction of abortion or to

Fig. 1. Case 3. M. L., age 26; married six years; one child four and a half years old. Last menses delayed five days, then bleeding very slightly, dizziness and nervousness. No syncope or pain. Uterus slightly enlarged. To right side is mass about size of lemon, follicle retention cyst. Curettings showed gestation glands.

Fig. 2. Case 4. R. R., age 24, married five years; one child four years old. Last menses delayed three days, then brownish stains for four days. Abdominal cramps especially on right side. Operation for ectopic pregnancy. Findings: corpus luteum cyst size of small lemon.

have done something to bring on the delayed menses.

In this group of cases, no matter what the patient's attitude toward her gravid condition may be, I have been obliged to think of three possible explanations for the clinical picture: (1) Delayed menstruation from some undetermined systemic cause, the mass lateral to the uterus palpated at one or more examinations being a "phantom tumor." (2) The mass lateral to the uterus is an ovarian cyst or cystic enlargement of the ovary. The pathological condition may account for the delay in the menstruation and the secondary enlargement of the uterus. The cyst in such cases ruptures spontaneously or through accident or trauma and its contents are absorbed. Bleeding follows upon the removal of this inhibitory factor. (3) Pregnancy is actually present either in the uterus or the tube or both, the embryo undergoes dissolution at a very early stage of its development without giving rise to the classical symptoms of early miscarriage or an early tubal abortion. The cystic condition in the ovary or the corpus luteum is secondary to this change. Further study and comparison with recent reports in the literature on this subject have led me to the conclusion that these explanations satisfy distinct pathological entities. The resulting symptom-complex is almost identical in all of them and the most careful investigation is necessary to separate one from the other. The possibility of a phantom tumor must also be taken into account but only in the sense that some of these retention cysts are encapsulated by a very thin cyst-wall which may rupture after the gentlest palpation and hence fail of discovery at a second or third examination.

Recently there came under my observation five cases which may be well included in this group of cases of suspected ectopic pregnancy. The first two of these were not operated upon. In the last three cases I have been able to examine and control the clinical findings by operative and pathological examination. They will therefore be reported in detail.

Case 1. C. W. First seen by me, July 24, 1915. Age 32, married 2 months; menses began at 13 years, always regular, 28-day type, 3 days' duration, unaccompanied by pain. Last menses July 22, 1915. She had had an attack of "peritonitis" seven years ago when she was confined to bed for two months. No urinary disturbances. No leucorrhœa. On examination July 24, 1915 she was a well nourished, athletic individual; cervix small, almost infantile; uterus small. There was still a small amount of sanguinous discharge from the cervix. In view of the history of urethritis and lues in the husband, the patient was examined for both these conditions. The husband's Wassermann test having

Fig. 3. Case 4. Curettings showed typical decidua of pregnancy. *d*, decidua.

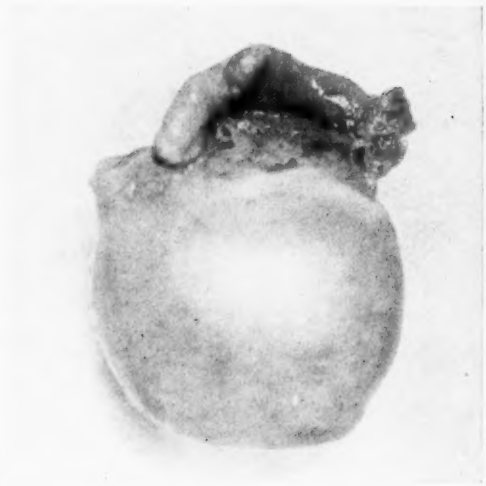


Fig. 4. Case 5. F. L., age 35; married nine years; 3 children, youngest three years old. Last regular menses January 11, 1916. Five days later again bled profusely; right sided abdominal pain. Clinical diagnosis: retention cyst of ovary versus ectopic pregnancy. Laparotomy January 12, 1916. Cyst of right ovary found, very thin wall, simple follicle cyst, scarcely any epithelium lining its inner wall. (No curettage.)

been negative before marriage, no further blood test was made in her. But smears taken from the urethra and cervix were negative for gonococcus.

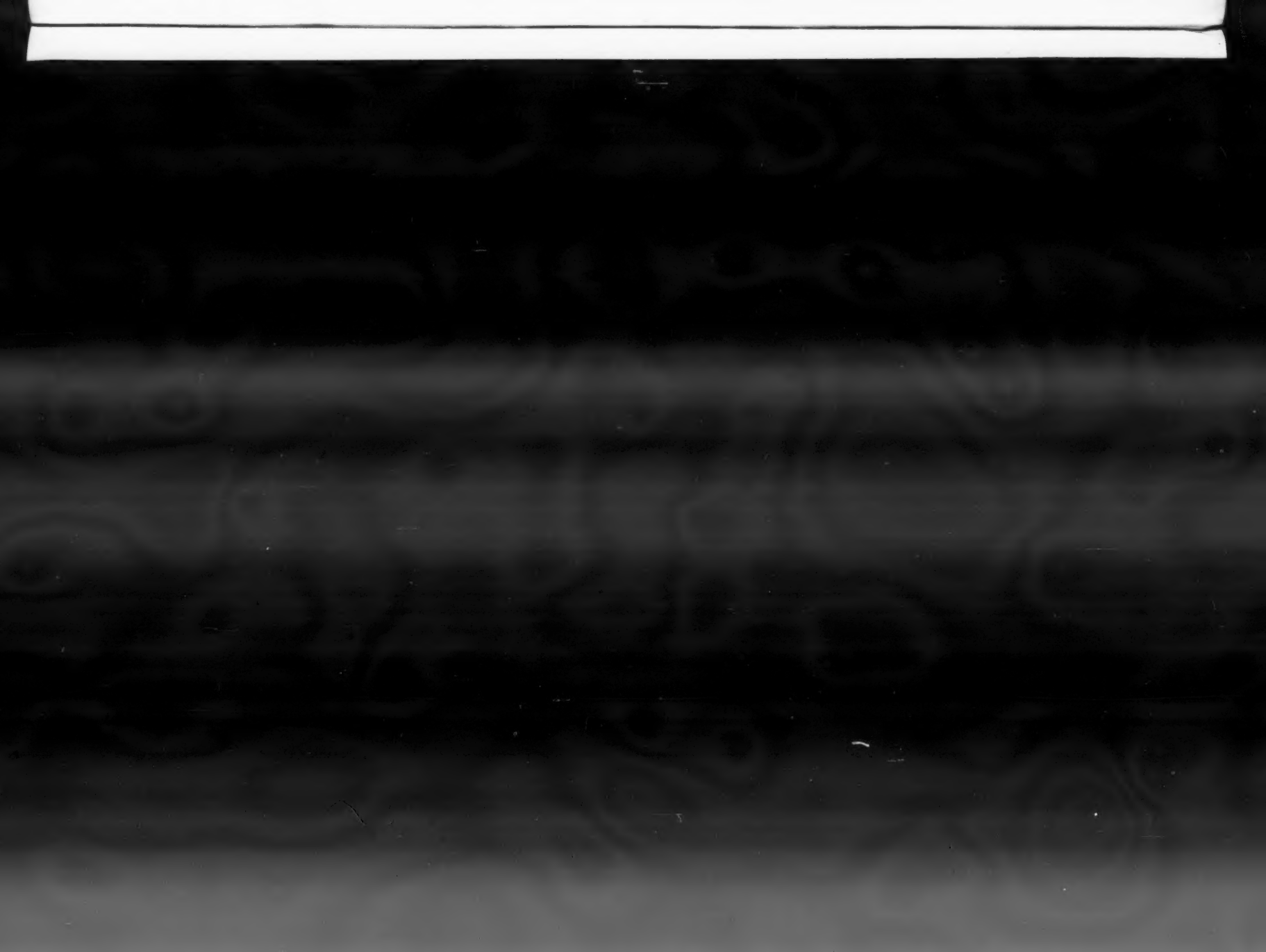
She was next seen September 4. Her period had not returned since her last visit. The cervix was decidedly softer, had a violaceous hue. The uterus was distinctly softer, larger, more anterior. The presumptive diagnosis was pregnancy. September 11, owing to an attack of severe pain in the left groin I examined her and found that the uterus was even a trifle larger than the week previous. The left adnexa were distinctly palpable, there was a small cystic mass present on the left side. The nature of this and its possible relation to her pain were at that time simply a matter of conjecture. October 4, patient reported that she began to stain and had experienced an uncomfortable feeling in the pelvis. There was no sharp pain or severe cramps. On examination I found that the uterus corresponded in size to at least *a two months' gravid uterus*. It was retroposed and there was more bulging from the posterior than the anterior uterine wall. A sanguinolent discharge mixed with mucus escaped from the external os. The patient was at once put to bed and kept quiet. Bleeding continued in a desultory manner, very small blood-clots passed without, however, giving rise to colic. At the end of three days she stopped bleeding. The uterus was then contracted; the mass on the side was no longer felt. In spite of the fact that she had had morning nausea and we had presumed her to be pregnant the patient was then allowed to leave her bed and the uterine condition apparently went on to complete involution. When next seen 8 days later the uterus was found to be in a contracted state and about of the average size.

The microscopic examination of several particles which came away with the escape of blood and which I removed manually from the vagina, failed to show decidua or chorionic villi. There were a few scattered mucous glands not sufficiently characteristic to draw conclusions.

Case 2. K. W. First seen by me March 27, 1912. Age 22, married 6 months. Was operated on for appendicitis three years ago without drainage. Six months later she was operated on again on account of severe abdominal cramps which were thought to be due to adhesions. She suffers from occasional cramps. Her bowels are regular; no urinary disturbances.

Menses began at 17, irregular, varying between 5 and 7 weeks before marriage. For the past 6 months the periods were regular. January 7, last regular period; clean to March 19, almost 10 weeks, when she fell and started to bleed. An attempt had been previously made in the fifth week of her amenorrhœa to induce abortion but without result. She had no fainting spells except on the day of her accident. She was curetted but continued to bleed.

Physical examination. Thin individual. Lungs and heart in good condition. Breasts are soft and nodular; colostrum cannot be expressed.



Both kidneys are palpable, the right one being deeper and tender. The abdominal scar shows a hernial protrusion at lower pole.

The cervix is small and hard. External os is patent and transverse; bloody discharge is slow. Uterus slightly enlarged and well formed. Sound enters 3½ inches to fundus; brisk bleeding followed the introduction of sound. Right adnexa are thickened; left adnexa are markedly thickened and very tender. It was not clear at the time whether patient had had an early miscarriage, whether she may have had an ectopic pregnancy, or whether the inflammatory condition of the adnexa was responsible for the symptoms. When next seen on April 8, the bleeding had stopped; the uterus was of almost virginal type; the right side was free; the left adnexa were tender and enlarged.

Her periods became regular again till August, 1913. When next seen, September 25, 1913, she had had amenorrhœa of 5½ weeks' duration. The uterus was again found enlarged and there was a soft elastic area over its anterior surface. Again there was enlargement of the left adnexa and a cystic mass very suspicious of an ectopic pregnancy. Four days after her visit she began to bleed and bled for 8 days; there was severe pain on the left side paroxysmal in character which required opiates. She then began to have dysuria and increased frequency of urination. There was no urethritis. This continued for several months. When seen on February 19, 1914; i.e., 10 days after her last regular period she was in good health. The uterus was anterior, of average size, and somewhat tender.

I lost trace of her for a year and a half. October 2, 1915, she stated that her periods were again regular occurring every four weeks till August 29. Since then she has been clean. The uterus was found high up, increased in size and corresponding to a 6 weeks' pregnant uterus. The left adnexa were distinctly palpable; there was a sausage-shaped mass which was tender to touch. Patient went clean for 7 weeks when she bled in the usual way but without pain.

Her history repeated itself again when on March 25, 1916, she reported an amenorrhœa of 6 weeks' duration with physical findings as before. Her weight in the course of the four years increased from 106 to 122 pounds.

Summary. A young married individual with repeated attacks of amenorrhœa of 5 to 10 weeks' duration with pain, occasional syncope, uterine enlargement and the presence of a mass lateral to the uterus. The data, in other words, were suggestive of an ectopic pregnancy. During the early postmarital months she was not desirous of being pregnant and sought to interrupt it. Later on she was very anxious to have a family and did not succeed. It is questionable whether she had been gravid at all, the histories of each attack are so much alike that, from my observations of her I could not say with certainty that she was ever gravid. If she was gravid at any time it must have been either an early terminated tubal or intrauterine pregnancy, associated with perverted ovarian or corpus luteum function. While laparotomy and curettage at one sitting would yield scientific data which in this case was lacking, it is not improbable in the light of the cases next to be reported that it belongs to the same group.

Case 3. M. L., age 26, married six years, one child four and half years old. Two miscarriages, the first two years ago; after delayed menstruation of 8 days, spontaneous bleeding; the second miscarriage one year ago was induced after an amenorrhœa of six weeks. Her periods with the exception of these two irregularities always appeared at twenty-eight day interval. So reliant was she upon the regularity of her menstruation that this time when she consulted me with the history which will follow she was very nervous and apprehensive lest she have an extra-uterine pregnancy. At the first menstrual delay, two years previously, her physician had suspected ectopic pregnancy but as her bleeding had stopped after a few days with no other untoward symptoms the diagnosis was considered doubtful.

December 29, 1915, the patient reports that her period was 5 days overdue, instead of bleeding freely she only stained; she had no pains but felt dizzy and nervous. She suspects not only pregnancy but some abnormal element in the pregnancy. On examination the uterus is found to be slightly enlarged and freely movable; there is bloody discharge from the external os. To the right of the uterus is a soft, thin-walled, cystic mass about the size of a lemon which is very tender and has great mobility as if it were suspended in a fluid medium. Patient placed under observation at a private hospital. Examination on three subsequent occasions confirmed the original findings. On the suspicion of an ectopic pregnancy I operated on her December 31. Preliminary curettage for diagnostic and therapeutic purposes. *Only hyperplastic* endometrial tissue was removed. There were no large organized particles suggestive of chorionic villi; the curettings were examined histologically. On opening the abdomen a moderate amount of sero-sanguinous fluid was found in the pelvis. A retention cyst as seen in Fig. 1 was found on the right side. The tube was long and patent, no abnormalities. The uterus was plump and in good position. The left adnexa were normal. There was no fresh corpus luteum in either ovary. In the one pole of the left ovary was a small grayish cyst about the size of a pea. The appendix was also removed as it showed evidences of chronic disease. It was examined later for the presence of decidual reaction.

Histological examination. The curettings in this case showed the characteristic gestation glands of Opitz with deciduous reaction in the stroma, which also contained a considerable amount of blood. Chorionic villi or syncytial trophoblast were nowhere to be seen so that the question of an

exceedingly early terminated pregnancy was left in doubt. The picture presented by the curettings could correspond with that as seen in the premenstrual endometrium as well as in very early pregnancy. Instead of the characteristic corpus luteum of pregnancy, there was this single retention cyst with a very thin wall containing a thin slightly stained fluid. The inner wall was lined by a single layer of poorly preserved cuboidal epithelium with here and there clusters of larger pigmented round cells with central nuclei that resembled lutein or psuedo lutein cells. This cyst could be said with certainty not to have originated from a corpus luteum, but belonged rather to the simple variety of follicle retention cysts with pigment cells.

CASE 4. R. R., age 24, married 5 years, one child 4 years old. No previous miscarriages. Her menses which began at 14 years of age were always regular and of the 30-day type. Patient was admitted to Beth Israel Hospital February 4, 1916, with the following history: Her menses had been delayed 3 days when she began to stain a brownish fluid which lasted four days. During the next three days on three separate occasions she bled as if her menses had come on. There were abdominal cramps and bearing down sensations in the right lower abdomen. Tenderness was elicited in the right and left lower abdominal quadrants. The uterus was enlarged to the size of about a five or six weeks' pregnant uterus; on its left side was a very tender mass, cystic and elastic to the touch, the size of a large plum. February 8, 1916, laparotomy. Uterus is enlarged and plump, appearance very suggestive of pregnancy. On the left side is a dark yellowish-brown cyst of the ovary occupying the greater part of the ovary and the size of a small lemon (Fig. 2.) It is bathed in a tinged fluid which fills the pelvis. In view of the clinical history and the normal appearance of the tube the idea of an ovarian pregnancy was entertained. The right adnexa were normal; the ovary containing a small corpus luteum in the regressive stage. It is of interest to note that during the patient's convalescence, she voluntarily confessed that she had had sounds introduced in order to induce abortion, whereupon the above train of symptoms followed.

Histological examination. The ovary is practically entirely converted into a cyst. The ovarian cortex is very thin and in isolated portions shows primordial ova and follicles. The corpus luteum cyst on section (Fig. 3) showed a well defined luteum border. The cells are in an excellent state of preservation. The conversion of the corpus luteum into a cyst must have followed the stage of florescence (Blueestadium, see below) as evidenced by the well preserved connective-tissue inner lining of the cyst. February 13, 1916; i.e., 5 days after laparotomy, the patient passed a membrane which showed on microscopic examination masses of decidua very distinctive of pregnancy (Fig. 3). There were, however, no chorionic villi or isolated syncytioplasm pathognomonic of pregnancy. The decidua was infiltrated with round cells and there was evidence of much blood extravasation. The glands were characteristic gestation glands as in Case 1.

Pathological diagnosis. Corpus luteum cyst associating very early interrupted pregnancy. If pregnancy as such could be excluded with absolute certainty, we should have in this case a unique example of persistent corpus luteum function with the formation of true decidua simulating clinically as well as pathologically an early uterine, ovarian or tubal abortion.

CASE 5. F. L., age 36; married 9 years; 3 children, the youngest 3 years old. Her menses began at 13, was of the 28-day type; her last regular menses was January 11, 1916, when she bled as usual for 5 days. Four days later she began to bleed again and lost large quantities of blood in free and clotted state. There were no urinary disturbances, no nausea or vomiting. She also complained of severe pelvic pain referred chiefly to the right side. There was a cystic mass about the size of a small orange (Fig. 4) very tender and slightly movable, distinct from the uterus which was of average size. *Clinical diagnosis.* Retention cyst of the ovary or ectopic pregnancy. On laparotomy a thin walled cyst of the ovary of a size previously estimated by palpation was found on the right side. It was incarcerated deep down in the pelvis from which it was dislocated. A small amount of serous fluid was found in the pelvis. *Histology.* Thin walled cyst, tunica albuginea well defined. Immediately underlying this is a loose vascular connective-tissue layer with *a flattened out layer of lutein cells* in the process of regression. The innermost lining consists of flattened cells resembling endothelium.

These conditions resemble each other very closely at times and lead not infrequently to confusion and embarrassment. How shall we interpret them? And how shall they be treated?

The rôle of the corpus luteum as an endocrinal gland. Thanks to recent advances in our knowledge of the cyclical changes in the follicle apparatus of the ovary, we are able to interpret in an entirely new light certain of these hitherto obscure gynecological phenomena. The corpus luteum which Born had declared in 1900 to be a gland of internal secretion has become recognized chiefly through the researches of Fraenkel as one of the endocrinal series of ductless glands. Fraenkel's clinical observations and animal experimentations have been amply proved by many other investigators. The histologic researches of Robert Meyer, Robert Schroder, R. Ruge III, and John Miller in 1912 and 1913 of the developmental phases of the cor-

pus luteum of menstruation and of pregnancy have completed the evidence essential to establish the fact that the corpus luteum exerts a specific influence over the physiological activity of the uterine mucosa. Furthermore, it is the structure in the ovary that represents the organ of internal secretion. This influence of the corpus luteum is manifest in (1) maintaining placental integrity and fœtal nutrition during the early weeks of pregnancy, (2) determining the pregravid changes in the uterine mucosa with the resulting formation of deciduous tissue, the soil in which the ovum is to be embedded.

If these changes bear a relationship of cause and effect under normal physiological circumstances, we ought to anticipate disturbances of such processes under pathological conditions involving the corpus luteum or the young embryo. Thus the formation of retention cysts especially of the lutein variety ought in some way to affect ovarian and endometrial function. And, conversely, early embryonal death should be accompanied or followed by degenerative changes in the corpus luteum. In order that we may appreciate the pathology and the clinical importance of these ovarian retention cysts, I will briefly describe the development and regression of the corpus luteum under physiological conditions as summarized by F. Kermauner.[1]

The corpus luteum: histogenesis and developmental phases. The rupture of the mature graafian follicle according to most observers takes place about 12 to 14 days after the first day of the last menstruation. Very soon conversion of this follicle into the yellow body begins. First those changes set in which may be included under the *stage of hyperæmia* and *proliferation.* The cells of the granulosa multiply to many times the number of original layers and take up fatty substances including lutein which impart to it its yellow appearance. The lutein cells are large and polymorphous, contain finely granular protoplasm, pigment granules, fat droplets and a vesiculated, for the most part centrally situated, nucleus. These lutein cells take the osmic acid stain and are said to contain colloid substances, a fact which is assumed to strengthen the hypothesis that they are of epithelial character as against the possible origin from the cells of the theca interna. The process of vascularization completes the stage of proliferation. Blood sprouts shoot up from the theca interna and with them connective-tissue strands which together result in the formation of a matrix or framework for the lutein cells; the latter are thus arranged into groups. The cells of the theca interna undergo a certain degree of change and are dislocated in isolated portions into the corpus luteum along with the connective-tissue strands. These are known as the theca-interna lutein cells in contradistinction to the granulosa lutein cells. However, the former are always distinguishable as the peripheral layer of cells.

In the center of the yellow body, there is frequently seen at this stage a coagulum, referred to as the central blood core. It is practically always seen in conditions other than pregnancy and it is maintained by some authors to be a distinguishing feature of the corpus luteum of menstruation. In the pregnant state, this "blood kernel" is practically never seen. However, this is a matter about which there is difference of opinion and the study of a larger number of specimens will have to be awaited before we come to final conclusions. So far, no distinct essential differences have been established between the corpus luteum of menstruation and that of pregnancy.

As the connective tissue penetrates the lutein layer more and more, the cavity is finally filled up and the *stage* of *florescence* or *Bluetestadium* is reached. Even the blood kernel may be thoroughly traversed by blood-vessels and become gradually absorbed. The lutein cells become gradually larger and more glistening; they are now seen to be surrounded by connective-tissue fibrillæ while the theca lutein cells begin to disappear. Then follows the *stage* of *regression;* the lutein cells appear unevenly stained, and the whole yellow margin becomes speckled, the connective-tissue becomes hyaline, that of the inner lining of the cavity as well. Occasionally a small cyst is the result. In place of the blood kernel there are now pigment

[1] Mss. to be published in Liepmann's Handbuch der Frauenheilkunde.

masses; the lutein cells themselves undergo necrosis and are gradually absorbed. In the clefts of the hyaline connective-tissue there remains for some time shrunken cells with irregular dark nuclei; very finely granular rests containing fat are retained. Through further shrinking and absorption, the whole structure is converted into a white and cicatricial mass stainable with eosin and resulting in the formation of the *corpus albicans fibrosum* which finally also disappears. If one examines sections of an ovary, one will frequently find corpora lutea in various stages of development and regression.

Should pregnancy set in, the stage of florescence is delayed to a point beyond the second month when a very gradual regression takes place. At the end of pregnancy the corpus luteum is still about the size of a pea and disappears entirely during the puerperium. Occasionally a corpus albicans of pregnancy may be recognized by its content of lime even after the puerperium.

During pregnancy the theca interna cells hypertophy very markedly, and this activity of the cells only stops postpartum. In hydatid moles this process finds expression in the formation of large polycystic tumors which, however, are benign in so far as they tend to regress completely. These proliferated theca interna cells represent the so-called *interstitial gland* of the lower animals. In the human subject they only appear during pregnancy and are often seen well preserved in the early puerperium.

Comparison of the cyclical changes in the corpus luteum and in the endometrium. By comparing the appearance of the corpus luteum and that of the uterine mucosa at certain intervals, R. Meyer and Ruge[1] have found that there is a striking coincidence in the several stages of the cyclical changes to be seen in both structures. Thus the hyperæmic or proliferative stage of the yellow body corresponds in point of time with the interval stage of the endometrium, the vascularization stage of the epithelial luteal border coincides with the premenstrual phase, the florescence stage is synchronous with the time just preceding the menses, while the stage of regression takes place during menstruation and thereafter. According to the same authors, the stage of proliferation occurs between the eighth and twelfth day following the onset of the menstruation, the stage of vascularization between the fourteenth and sixteenth day. The stage of florescence between the seventeenth and the twenty-eighth day while the highest degree of activity of the lutein cells, as estimated by the greatest amount of swelling, takes place about 2 days before the menstrual period. Active regression then follows till 8 days or so after the beginning of menstruation while complete regression is variable and is sometimes much delayed. These estimates refer to menstruation of the 28-day type.

There seems, therefore, from this comparison of the cyclical changes in the two structures to be an intimate connection between them. If the corpus luteum can determine the pregravid changes which Fraenkel, Loeb, and others have definitely proved, then it may be properly assumed that in all probability it is also responsible for the induction of the premenstrual changes. Between the latter and the pregravid changes there is only a quantitative difference. Essentially the glands and the decidua are alike. If the ovum is impregnated, the decidua becomes more abundant and more conspicuous. If the ovum is not impregnated, menstruation sets in. In this connection it is well to mention that menstruation as such is really not a positive uterine function. Nor does it result directly from the presence of a corpus luteum any more than pregnancy results from the same. Menstruation sets in if the ovum is not impregnated (ovum abortion of Loewenthal). The swollen and hypervascularized mucosa, induced through the influence of the corpus luteum is by means of the menstrual flow again restored to its normal state. Possibly with the retrogression of the corpus luteum consequent upon failure of the ovum to be fertilized there is either a disappearance of the substance or substances which inhibit bleeding or a regressive change sets in within the deciduous endometrium that results in the liberation of tryptic substances on the

[1] R. Meyer and Ruge; Arch. f. Gynaek., c, No 1. 100.

one hand and in antithrombinogen on the other. The effect on the vessels is increased dilation of the capillaries with rupture and bleeding. These substances are purported to have been isolated by Seitz, Winz, and others.[1] Whether we can imitate the physiological exchange of these substances in now causing diminished bleeding and again increased bleeding the future alone may tell. The good results reported from the use of corpus luteum and of apotherapy in general cannot be satisfactorily explained until we have more precise knowledge of ovarian hormones. At present we may grant the existence of these two substances within the corpus luteum exhibiting antagnostic properties. I venture the hypothesis that possibly the two substanecs are derived from the two varieties of lutein cells normally found in the corpus luteum; i.e., the cells arising from the granulosa epithelium, the lutein cells proper, and those arising from the theca interna cells, the theca lutein cells. These two varieties of cells may lodge in them antagonistic substances not unlike the cells in the anterior and posterior half of the pituitary gland.

Retention cysts of the ovary in relation to delayed menstruation, enlargement of the uterus, etc. If the corpus luteum establishes those changes in the uterus that under normal conditions are intimately connected with pregnancy and menstruation, it is not illogical to assume that pathological alterations of that gland should be associated with disturbances in both of these functions.

First let us briefly describe the origin and pathology of ovarian retention cysts. We will follow the description of O. Frankl[2] also, in reference to certain degenerations of the impregnated ovum, viz.; hydatid mole, chorioepithelioma, and early dissolution and absorption of the embryo.

Retention cysts of the ovary. Under certain conditions as pregnancy, inflammation and circulatory disturbances, large numbers of follicles undergo degeneration. Under the influence of pregnancy, chiefly, the larger maturing follicles are inhibited in their growth and they are said to undergo either obliterative or cystic atresia. The latter process usually affects the larger follicles. The granulosa cells and the theca interna cells may be completely degenerated and disappear or there may arise in the atretic follicles especially under the influence of pregnancy, a large number of lutein cells. The retention cysts that result are of two varieties: (1) simple follicle cysts with or without lutein cells; (2) corpus luteum cysts. The cysts may reach the size of a walnut to an orange or in rarer instances to the size of a child's head. The largest cysts are mostly without lining epithelium and the ovarian tissue becomes replaced by the cyst. Under the influence of inflammatory hyperæmia, the larger maturing follicles may undergo atresia with cyst-formation. Through confluence of such retention cyst with a hydrosalpinx, a genuine tubo-ovarian cyst may result. The retention cyst in such a case may be lined with lutein cells. The theca cells of the atretic follicles form abundant lutein cells; also all the granulosa rests tend to produce lutein cells.

The corpus luteum of pregnancy does not tolerate the maturation of any follicle; there results, therefore, cystic atresia of numerous follicles. At the same time through hyperæmia, an abundant transudation is brought about in the follicles that have become cystic and atretic. There results in this way follicle cysts with very active lutein cell formation, the cells originating chiefly from the theca interna. At the same time the corpus luteum can also undergo cystic dilation.

The corpus luteum cysts first described by Rokitansky are to be distinguished from the follicular lutein cysts. They are dilated cystic corpora lutea and consist of a single chamber lined with a very thin wall and very seldom attain a large size. The cavity is filled with a yellow fluid and lined with a yellow brown internal membrane which may be separated as a capsule. Through infection, abscess formation in the cysts may take place; rupture and hæmorrhage may also take place (Pankow, Roll).

The histological examination of the corpus

[1] Seitz, L., Wintz, H., and Fingerhut, L. Ueber die biologische Function des Corpus Luteum; Seine chemischen Bestandteile, etc. Muenchen. med. Wchnschr., lxi, Nos. 30 and 31.

[2] Liepmann's Handb. d. Frauenh., 1914, ii.

luteum cysts presents various pictures depending on the stage of development of the corpus luteum. Cystic dilation follows transudation into its center and finally, according to the size of the cysts and the effect of the pressure of its contents, the ovarian stroma may be reduced to the minimum. The diagnosis is not difficult when one still finds well preserved granulosa lutein cells which are arranged in the characteristic fashion as seen in the corpus luteum. In case of the cyst occurring at the time when the corpus luteum is in its stage of florescence there may be found a layer of connective tissue lining the lutein cell border, occasionally the latter is represented by a hyaline margin containing pigment masses.

Cysts in mole and chorio-epithelioma. In about half the cases of chorio-epithelioma there are found corpus luteum cysts and genuine lutein cysts. After Seitz and Wallart it may be assumed that the same process takes place in the ovary associating mole or chorio-epithelioma only in an excessive degree as it takes place in normal gravidity. Fraenkel claims that instead of the corpus luteum graviditatis in tubal pregnancy there is often a corpus luteum cyst but the causal relationship is not established. It may be secondary to the tubal pregnancy as well as primary due to hyperæmia, irritation, etc.

The early dissolution or regression of an impregnated ovum in relation to corpus luteum cysts. Fraenkel has shown that in lower animals spontaneous degeneration of a very young embryo is a frequent occurrence. In the rabbit, for example, of the twelve pregnant chambers (average number of pregnancies at one time), a few do not reach maturity; but on the contrary these retrograde, become harder, irregularly nodular and smaller and disappear entirely while others develop fully. These affected pregnant locules are situated at various points between the retained pregnancies either to one side or between them.

Removal of the corpus luteum or castration causes interruption in all the pregnant chambers provided this is done before the second half of pregnancy. If done later this cannot be accomplished. The time of disappearance of the pregnant ova varies between 3 to 10 days. At first the liquor amnii is absorbed, then the degenerated embryo approximates the placenta which meantime likewise becomes smaller, pale and dry. The embryo shrinks very rapidly to a white grayish strand-like structure that becomes recognizable merely by the spinal column, dissolves altogether or becomes confluent with the placenta (membranes are no longer to be recognized at this stage) resulting in a solid, grayish hemispherical mass or in a mushroom-like structure which becomes smaller from day to day. Finally it consists of a few particles of detritus and disappears altogether. The ovular chamber is later to be recognized externally by a mildly spindle-shaped swelling, and by its increased hardness. Internally 2 to 3 smaller mucous membrane folds having a longitudinal, mesometral direction mark the place where formerly the embryo lodged. Occasionally one finds at these points amorphous, cheesy material or fluor which does not always make its appearance from the vagina because it is usually blocked by the intervening locules. At the end of pregnancy there is no trace of the degenerated ova, particularly if the process began early.

In Fraenkel's experimental production of this regressive process, i.e., during the first half of pregnancy, no bone formation had yet occurred; hence complete resorption took place. This is possible so long as bone has not yet been found. After the eighteenth day of pregnancy in rabbits osteoid tissue is to be found; also calcified cartilage tissue.

In another series of experiments one ovular chamber with its contained fœtus was removed for control purposes while at the same time the corpora lutea or the ovaries were also resected. The remaining pregnant locules were then traumatized by squeezing them. In a number of these experiments he succeeded in causing the regression of a number of locules thus treated and at the same time proved the possibility of intrauterine digestion or dissolution of bone. Fraenkel observes that nothing remarkable is thus proved because regression of bone or the dissolution of calcium has been observed under other circumstances.

In the human subject this process does not follow as closely as in animals. Doubtless it is possible for a retained embryo to die, become very soft so that it melts between the fingers and then become disintegrated in even a closed ovular sac. However, cases were not described till very recently in which *an entire intra-uterine ovum becomes absorbed.* If pregnancy was assumed with the greatest degree of probability and later not found it was natural to assume that a mistake in diagnosis was made. In a case which required bilateral ovariotomy, Polano[1] and Fraenkel each observed and demonstrated a pregnancy corresponding by physical signs to the skipped period.

In Polano's case it was a four months', in Fraenkel's case a two months' pregnancy. The postoperative course was controlled very carefully. *No bleeding or escape of any sort was observed.* At the time of discharge of the patients from the clinic the uteri had returned to their normal size; by further observation it even appeared smaller as in castration atrophy. Case 1 of my series would fit in precisely with this peculiar type of embryonic pathology.

Polano found that the ovarian tumors in his case were lutein cystomata and hence assumed, particularly on account of the unheard of phenomenon of the regression of so large a normal ovum, that he was dealing with a hydatid mole. John Miller reported another case about the same time from Menge's clinic. In his case the corpus luteum gravidarum was converted into a cyst. Pregnancy was established by laparotomy when the cystic tumor was removed. The uterus subsequently under very careful observation diminished in size and returned to normal without any external abortion having taken place. These three independent observations, which can scarcely have been exaggerated clinically, have all in common the removal of the corpus luteum cysts; in other words the same etiologic cause as has been first demonstrated experimentally in the animals. One, therefore, assumes that the removal of the protective glands of pregnancy leads to the disposition especially of this peculiar form of ovum degeneration. In animals with multiple fœtation this occurrence is frequent. In the human species it is the exception and Fraenkel observes that it is probably brought about only by means of this technique. Fraenkel further adds that the period in which the corpus luteum influences pregnancy in women is apparently very limited and varies in different individuals so that even after bilateral oophorectomy at an early stage of gestation further normal development of the ova has been observed.

[1] Polano; Ztschr. f. Geburtsh. u. Gynaek., vol. lix.

SUMMARY AND CONCLUSIONS

Menstruation in married women is often delayed for periods varying from a few days to a month. During this period of temporal amenorrhœa, the patients naturally regard themselves pregnant. Not infrequently physical examination in such cases of delayed menstruation will reveal the uterus actually changed in size and consistence thus further justifying the presumptive diagnosis of pregnancy. However, in spite of this subjective and objective evidence, the diagnosis may be left in complete doubt by the onset of the menstrual flow which *apparently differs in no way from the usual menses* for that particular individual. Occasionally in addition there may have been found on palpation an extra-uterine mass, more or less tender, which excites the suspicion of an ectopic pregnancy. This extra-uterine mass may make the impression of an enlarged cystic ovary or be more or less elongated and simulate an enlarged dilated tube. Pain in the lower abdomen and cramps may also be complained of. In other words there may be present the essential points in the history and physical findings of the patient to lead to the diagnosis of an ectopic pregnancy. Occasionally too, the cystic mass may be unmistakably ruptured by the examining fingers thus further simulating a ruptured ectopic gestation sac. Yet neither in the subsequent course nor at laparatomy is an ectopic pregnancy proved. Instead, a retention cyst of the ovary varying in size from a plum to a small orange is the only abnormal finding. This cyst may be a simple retention cyst histologically with or without lutein cells, or it may be a genuine

corpus luteum cyst. These arise either as a result of early death of an intra- or an extra-uterine embryo, the subjective symptoms being wholly due to the gestation itself; or arising as a result of trauma or degenerative changes in the ovary, the corpus luteum cyst may induce secondary changes within the uterus, enlarging it, softening it, prolonging the decidual (pre-menstrual) phase, and inhibiting the onset of the menses.

From an analysis of the histologic findings in the cases personally encountered, it appears that corpus luteum cysts and retention cysts of the ovary may simulate early terminated intra- or extra-uterine pregnancy without either of these conditions actually having been present. On the other hand it is more likely that in the majority of instances these retention cysts result secondarily through early embryonal death whether the impregnated ovum lodged within the uterus or within the tube. The ovum is in these instances disintegrated and absorbed and restitution (involution) takes place without the external or internal hæmorrhage which we are accustomed to see in uterine or ectopic abortion. In all probability a great many non-tragic ectopic pregnancies terminate in this way.

OBSERVATION OF A SENIOR SURGEON COMMANDING THE SURGICAL DIVISION OF A BRITISH BASE HOSPITAL IN FRANCE[1]

By KELLOGG SPEED, M.D., F.A.C.S., Lieutenant-Colonel R.A.M.C. (Hon.), Chicago

FROM France last July I had the pleasure of contributing to the *Journal of the American Medical Association* a letter which considered briefly the excellence of organization of the Royal Army Medical Corps of the British Expeditionary Forces in France and also in a minor way ballistics and war wounds. The present paper is purely surgical and very general in its scope.

GENERAL REMARKS

The training and health of soldiers who exercise freely, marching fifteen miles a day carrying an extra weight of fifty-six pounds, who live an outdoor life, have no alcoholic drinks and who are fed on an abundance of good plain food have considerable bearing on their general ability to resist shock and infected wounds.

Fighting conditions are very unfavorable. Trench warfare is waged in ditches nine feet deep. The soldiers operate in mud and dirt. There is lack of exercise and frequently bowel stasis. The difficulty of transportation of wounded through communicating trenches, the compulsory exposure to the elements while lying out waiting to be picked up, and the complications caused by secondary wounds received while lying, in transportation, or even in dressing stations from enemy fire are also important factors. We received men who had lain as long as six days in the open with no attention, no food nor drink, and frequently with large areas of painful sunburn from exposure.

Care and supplies are excellent. Rubber gloves, surgical dressings, medicines, and splints are liberally furnished. Iodine is falling off in use as a part of first aid dressing, cyanide gauze is being largely substituted for it. Casualty cleaning stations, the collecting points of several field ambulances, are also being discontinued as the great benefit of immediate transportation to the near base hospitals is appreciated. There is not time for any reference to the distribution of wounded to special hospitals in England after their removal from the base.

Pathological and bacteriological study is encouraged. There is also co-operation between base-hospital units with discussions of general principles in open meetings and through the medium of surgeon-general consultants. There should be granted greater freedom to medical officers to report special series of cases and results of particular treat-

[1] Read before the Chicago Surgical Society, December 8, 1916.

ments. Opium, especially morphine, is used freely for wounded men at the front. It is generally given by mouth and doses of one-half grain are common after injury or before transportation.

CASE GROUPS

At base hospitals it seems wise to separate the wounded into different wards according to the types of injury. I used a system of distribution which gave a head ward, chest ward, buttock ward, fracture of femur ward, etc., and found that it helped both medical officers and nursing sisters and was a great convenience for the officer commanding and especially time-saving for consultants.

1. *Punctured and lacerated wounds* form the majority of all admissions. They exist with or without bone involvement and foreign bodies. Routine treatment consists in early excision of ragged edges and removal of the foreign body, the wadding, if cloth, being as important as the metal. Gas anæsthesia often suffices. The X-ray must be used in co-operation. Experience lends the surgeon an ability to follow fresh wound tracts and keen observation of extra tender spots may betray where foreign bodies lie. One must not make the mistake of opening limbs filled with blood unless the infection has become alarming and then preparation for large vessel ligature must be at hand. The X-ray is of great value in making an early diagnosis of gas infection.

Practically all wounds trimmed and searched for foreign bodies demand drainage. Large fenestrated or split tubes are the best means of affecting this and are combined with installations of eusol (Dakin's solution). This solution can be injected into the tubes every two hours by the nurse with a small hand syringe or can be used by the drop method from reservoirs. If dressings are put on wounds, irrigation keeps them constantly moist and mechanically flushes the wound. Deep infection disappears and healthy granulations appear more quickly with this solution used in this manner than with any other irrigation I have ever seen used. Limbs so treated are slung in splints and kept at rest. Vaseline is not necessary on the skin surface if this solution is made up fresh daily as follows:

Eusol. 0.5 per cent aqueous solution of hypochlorous acid. Shake up 12.5 grams of boric acid powder and 12.5 grams chloride of lime (bleaching powder) with 1 litre of water; allow to stand a few hours, then filter. The chloride of lime must be dry. The solution *will* remain efficient about three weeks. Stronger solutions do not keep. It should be stored in colored bottles and because it is destructive to cloth and corrodes metals, all instruments should be washed after contact with it. Eupad, a powder composed of equal weights of boric acid and dry chloride of lime ground together will keep in stoppered bottles.

The use of eusol intravenously in 25 to 50 cubic centimeter doses has been advocated in extensive sepsis. Although I have tried this without untoward effect, I doubt its value.

Hypertonic salt solution 5 to 10 per cent is also used as a wet dressing or irrigation on suppurating surfaces. When the solution is not at hand, large wounds may be lightly packed with 10 to 20 salt tablets, which dissolve in the serum and form a hypertonic solution on the surface. This treatment has a distinct value.

2. *Head injuries.* The use of the steel helmet is an important factor in lessening the severity of head wounds. The important aspects of these wounds may be roughly divided into the fractures, infections, deeply lying foreign bodies, and the sequelæ.

Colonel Warren, in a report made to Sir Alfred Keogh, D.G., in July studied the fate of 1,239 head injuries between 2 and 18 months after infliction of the wound. Seven hundred of these patients were observed in France and full clinical histories made. Mere scalp wounds were excluded unless they led to death or serious complications. All were *severe* cases. The mortality was less than 4 per cent, none dying after three months from the date of wound. The majority died of meningitis. This was my own observation also, as I hope to show in a series of cases to be reported later. Ventricular infection is always fatal. Colonel Warren found no fatal case in which death occurred in England when the dura mater was not lacerated by wound or by operation.

Probably much of the early sensory and motor disturbances are caused by œdema and circulatory disturbances in the brain. Recovery without interference is possible even in face of complete hemiplegia and deeply lying foreign bodies. Infection is the condition most to be feared.

a. *Permanent mental disturbances* are very rare. I saw two. This does not include shell shock. Major Mott, Pathologist, London County Council Asylums, says: "Head injury, apart from syphilis, alcohol, and hereditary neuropathic taint, was seldom the cause of mental affection."

b. *Epilepsy* is less common than believed. I saw several cases resulting from injury. Colonel Warren found 6 per cent. Every head case should be given bromides early to avoid formation of the epileptic habit.

c. *Other neurological complications* are either objective, as paralysis, sensory and visual disturbances, or results of cerebral hernia and septic infection. There are also frequent subjective symptoms — the most common are headaches, fatigue on exertion, throbbing, attacks of dizziness, and some changes in temperament — or hysterical manifestations. Many of these are like traumatic neurasthenia and while they incapacitate from active service, they are recoverable and are independent of fracture and whether the patient has been operated on or not.

d. *Cerebral hernia* is fairly common. It is difficult to treat and gives a mortality of 20 to 40 per cent. Colonel Warren found 24 per cent mortality in cases evacuated to England with cerebral hernia. Of course many die at base hospitals.

e. *Retained missiles in brain.* Soldiers very frequently recover with much betterment of condition and frequently with no trace of damage. English surgeons as a rule are opposed to head operations.

My experience leads me to conclude that in superficial foreign bodies with open wounds one should do a quick removal as in other parts of the body, but do no damage. Make every effort to avoid hernia cerebri.

Emphasis must be laid on spinal puncture for its therapeutic and diagnostic value.

Late results in head cases are unexpectedly good. Cerebral abscess, insanity, and epilepsy are rare.

3. *Spine injuries.* The symptoms are more definite and less liable to ameliorate than in head injuries. If the evidence shows severance of the cord or a septic tract to the cord, the dura should not be opened. Foreign body or bone pressure on the cord is amenable to operation. Operative opening of the dura invites infection and the meningitis is more or less atypical in symptoms. At post-mortem there is a diffuse plastic suppurative meningitis over a large portion of the cord, death generally occurring when the bulb becomes involved. Cases not operated upon frequently live a long time or even overcome infection so that they can be carried home in spite of paraplegias and other hopeless paralyses.

4. *Neck injuries* are frequent and in spite of anatomical condensation of that part of the body, many are unimportant. Serious ones die on the field. At the bases are found aneurisms, both false and arteriovenous. Nerve injuries, thyroid injuries with intracapsular hæmorrhages, presenting symptoms much resembling hyperthyroidism are met. I had four cases of injury of the cervical sympathetic and five cases of gunshot of the thyroid. Tracheal injuries heal quickly as a rule. Complete lesions of the brachial plexus are rare and one should be slow in making such a diagnosis on account of recoveries which will follow what is apparently a complete severance.

5. *Chest injuries* are common. All types of chest pathology ensue. Old pleural adhesions which prevent lung collapse when the pleural cavity is opened may be the cause of fatal hæmorrhage upon lung perforation. Pneumothorax is frequent. Great displacements of the heart right themselves in a surprisingly short time if relief is given by aspiration or drainage. Empyema follows frequently. It often develops after the third week and becomes urgent. All collections of fluid in the thoracic cavity should not be drained until aspiration with a vacuum apparatus and bacteriologic examination have been made. Fluids sterile a few days after injury will frequently go on to empyema in the

fourth week. Suppurative pericarditis is easily overlooked. Drainage of empyemata once established should be thorough and at the lowest point. It is often done under local anæsthesia. The mortality of chest injuries reaching the base does not exceed 5 to 6 per cent. Convalescence should be in special wards or outdoor hospitals.

6. *Abdominal injuries* are for the most part operated on in field ambulances. Extensive resections of gut are unwise because death follows after a delay from sepsis or the combination with adhesions and obstruction. Some cases reach the base undiagnosed and are clamant indications for immediate operation, if only on suspicion. A sharp eye must be kept for *extraperitoneal* injuries. Their manipulation and drainage must be made without endangering the abdominal cavity. I had a series of six interesting gunshots of the psoas muscles, without abdominal involvement and was able to drain extraperitoneally and save three of them, although they presented fresh *psoas abscess*, a rare condition. Not one of these cases pointed in the femoral region where we expect all old psoas abscesses to show themselves. All had flexed thighs on the affected side, extension of which was painful.

Bladder injuries give poor prognosis.

Injuries of the external genitals heal nicely, but demand long care and later plastics. Buttock injuries are obviously difficult to care for. I found that support on the Bradford frame with air dressings gave the best results.

7. *Extremities.* All types of injuries, from simple through-and-through punctured wounds to massive open fractures are found. They are treated on the general principles of wounds, except that through-and-through punctures from rifle and machine gun bullets are usually left alone and frequently heal with no reaction. One must be on guard against blood-vessel injury, gas infections, and mere contusion of nerve-trunks which cause only temporary paralysis. In gunshots of the leg nail extension is a sure method of obtaining continuous traction.

8. *Nerve injuries* are relatively not common. Paralyzing contusions which at first seem complete severance of main trunks will often show complete recovery in three to four weeks. One should be slow in making diagnosis and never operate in the presence of infection.

9. *Blood-vessel injuries.* Are interesting and are often overlooked unless there is immediate alarming hæmorrhage or a quickly forming aneurism. Vein injuries lead to great distention of a limb which in a few days simulates either extensive pyogenic or gas infection. If these limbs are operated on early, vessels generally have to be tied at a distance both proximally and distally. Thrombosis and emboli occur when the infection is late in manifesting itself with resulting ligation of main trunks or amputations. As a rule they are best treated expectantly. Examples of pure arteriovenous aneurisms, especially of the femoral or brachial, come into the base hospitals. Arteriovenous aneurism with false sacs adjoining and ordinary false aneurism are also seen. It was my good fortune to deal with many of these. Dr. Hugh Cabot with the Harvard Unit told me that he had seen none on his service.

Secondary hæmorrhages are numerous. I have complete records of more than thirty cases, many of which ended fatally. The cases threatening hæmorrhage are best cared for in a separate ward with constant watch and air dressings. The femoral, cranial, axillary, and gluteal vessels give the worst prognosis. The types of infections in war wounds lead frequently to vessel softening and thrombosis, and ligatures should be applied at considerable distance from the wound.

10. *Tetanus.* Occurs in spite of prophylactic injections of antitoxin. I had six such cases, all treated by massive and repeated doses of antitoxin, intraspinally, subcutaneously, and intravenously. Treatment should be started as soon as first symptoms are noticed. Especially interesting are the cases of *local tetanus.* Of these I saved every case which came into the service by the above mentioned treatment, sometimes added to by injection of 2000 units of antitoxin in the main nerve-trunks of the limb.

11. *Gas gangrene.* May be divided into

two types — local and general; that is (a) involving one muscle or one group of muscles in an extremity or (b) massive and general extending quickly up a whole limb. We found that there were four different groups of organisms to be isolated: Welch's bacillus, bacillus capsulatus aerogenes, a coccus, and an organism closely related to the colon group. With the local infections the prognosis is good after early operation. The skiagram often shows beginning gas formation about foreign bodies and indicates immediate thorough drainage. Amputation is used for the general extremity gas infections, and if the extension has been very rapid, even this will not save a general septicæmia and death. In Welch bacillus infections the muscle tissue becomes a pinkish salmon-like color with the same colored discharge. Other organisms give a soft degenerated muscle which is like soft clay, brownish in color, resembling fæces in odor and consistency. At operation all such degenerated tissue should be scooped out by the surgeon — the whole length of a limb opened if necessary to make the removal.

12. *Gas poisoning* is also of two classes. Chlorine is the chief constituent of the drift gas. Asphyxiating and lacrimating shells contain other gases, the lacrimating type causing a profuse outpouring of tears and pupil dilatation so that artillerymen and other gunners lose efficient eyesight. The pathology divides itself into that found in the cases gassed to death from general toxic effects, those which develop lung œdema and bronchopneumonia, and a third class which develops secondary septic bronchitis, pleurisy and pneumonia. The gas helmets and use of atropine and oxygen have become routine treatment.

13. *Amputations.* Like any civil surgeon I entered war surgery with the most conservative ideas regarding amputations. I now believe more early amputations should be performed. One must consider all the usual rules of civil practice regarding sites, subsequent joint movements for artificial limbs, etc., while the method of amputation is dictated by the severity of infection expected or already present. "Guillotine" amputations, circular with no flaps, give excellent drainage and can often be made to suffice without further limb shortening by use of the stump splints and secondary bone amputation where granulations are clean. Some of the worst cases of gas infection I saw followed amputations with sutured flaps.

Amputation with spinal anæsthesia is very satisfactory and often possible when a general anæsthetic dare not be given.

The military surgeon constantly meets his old civil friends even in the rush of battle-wounded men. Appendicitis; hernia; cholecystitis; urinary retention; mastoiditis; bone tumors and cysts; and stomach ulcer, bleeding or perforated; appear with the mass of other material, and diagnosis must be as keen and prompt as under other conditions. We found it possible to do the cleaner and aseptic surgery on cases demanding it, although we also dealt with so much sepsis. Ether still remains to my mind the anæsthetic of choice for serious operations.

I take advantage of this opportunity to thank the members of the Chicago Medical Unit, British Expeditionary Force, for their co-operation and to express regret that the Unit ceased to exist because we were unable to obtain reinforcements.

ODONTOMATA[1]

With Special Reference to their Classification

By CHARLES W. BONNEY, M.D., and A. G. ELLIS, M.D., Philadelphia

THE histories of the cases upon which Doctor Ellis's pathologic report is based are as follows:

The patient from whom the larger of the two tumors was removed was a middle-aged colored woman, who stated that to the best of her recollection, the trouble in her lower jaw began about fifteen years prior to the time she consulted me. Upon several occasions punctures had been made into the growth through the mouth, and some fluid evacuated. Marked increase in the size of the tumor had taken place within the last two or three years. Her chin and the left side of her face along the alveolar process of the jaw were very much enlarged and the floor of the mouth was almost entirely obliterated. At first sight she looked like a person who had acromegaly.

The operation, which was done under ether narcosis, consisted first in making an incision within the mouth over the most prominent part of the tumor and then stripping back anterior and posterior flaps of mucous membrane, after which the growth was broken into with a chisel and the evacuation of its contents, both liquid and solid, and removal of its walls were begun. It was a multilocular cyst containing for the most part thick chocolate-colored fluid. As the wound thus made was found inadequate to effect sufficient removal of the diseased tissue, a second incision was made at the junction of the anterior flap and the lower lip in such a manner that the soft parts covering the chin could be dissected free and turned down together with the lip like a curtain over the margin of the alveolar processes. This gave a sufficiently large field to remove the greater part of the cyst. However, some of the anterior wall was left in order to retain the normal shape of the chin. The cavity was lightly packed with gauze and the soft parts sutured into place. The patient became restless and left the hospital a few days after the operation. She was seen about six weeks later, at which time the cavity in her lower jaw was very much reduced in size. Her appearance was much improved by the operation.

The other case was that of a woman who had been operated upon twice before, the first operation having been done thirteen years ago by the late Dr. William J. Roe and the second one six years ago. There was a slight enlargement of the body of the left mandible, which was better outlined, however, by examining through the mouth. A portion of the tumor, including both mucous membrane and bone, was removed with the scissors and the contents evacuated. The patient has not been seen since she left the hospital.

With reference to the different diagnoses given in the two cases in which Doctor Ellis has shown that the tumors were structurally identical, I was under the impression that in the case of the colored woman I had to do with a tumor of more complex structure than the one in the other case. I thought that very likely the tumor might contain enamel and a greater proportion of other solid elements. Hence the clinical diagnosis of cystic odontoma. Inasmuch as Doctor Ellis has enumerated fifteen different names for this type of tumor, it would seem to the clinician that any term he might apply to them would be little better than a guess.

There are two points which I wish to make with reference to neoplasms of this kind. The first is that they can almost always be attacked and successfully removed through the mouth, as it will usually be possible to displace the soft parts covering the bone and then suture them into place again after the tumor has been removed, as was done in the case of the colored woman. The second point is that clinically these tumors are benign. In our second case Doctor Ellis found sections containing areas suggestive of epithelial infiltration. In a considerable number of cases in which similar microscopic findings were reported, the late Dr. Roe had the opportunity of watching the patients for years and in not a single case did malignancy develop, even though recurrence took place as it did in the case in question.

PATHOLOGY

Odontomata are not rare tumors but the many views regarding their classification may justify a report of two cases. The different diagnoses from the gross appearance of these two specimens, although microscopically the same in type, suggested, in addition to a discussion of that variety, a general review of

[1]Read before the Pathological Society of Philadelphia, March 9, 1916.

the classification of these tumors. To that phase of the subject therefore this part of the paper is largely devoted.

One of the shortest and best of the many definitions of the tumor under consideration is that of the Committee of the British Dental Association (1): "An odontoma is a tumor derived from the special cells concerned in tooth development."

A brief description of those cells from which the teeth arise will help make clear certain statements regarding tumors originating therefrom. The epithelium lining the mouth cavity sends into the developing jaw an ingrowth, the dental ridge or shelf. Into the under surface of this epithelial ridge, at the site of each future tooth, projects a mass of connective-tissue cells known as the papilla. Between the indentations thus formed the epithelial cord later divides, so that over each papilla is a separate mass of epithelial cells. Each of these spreads out over its papilla as a cap, called the enamel organ. This organ (the epithelial portion of the tooth) has three types of cells: the inner layer, next the papilla, is of tall cylindric cells (ameloblasts or adamantoblasts) that lay down the enamel; the outer layer is of low columnar or cuboidal cells; the bulk of the organ between these two layers is of cells connected by short processes, giving them more or less of a stellate appearance that is often suggestive of myxomatous tissue. The papilla is the connective-tissue portion of the tooth and from it develop the dentine, cementum, and pulp. The fibrous wall surrounding all these structures is known as the sac or tooth follicle.

An odontoma, therefore, may arise from the enamel organ, from the papilla, from the tooth follicle, or from the whole tooth-germ, depending upon which of these structures is concerned in producing the abnormal growth. This makes possible simple or complex tumors of varied structure, epithelial or connective tissue, or both, in type. For these reasons the difficulties of classifying odontomata appear not less than those encountered in connection with tumors of other origin.

Most writers of recent years follow more or less closely the divisions given by Bland-Sutton (2). He names the odontomata, from the part of the tooth-germ concerned, as follows:

1. Epithelial odontoma: from the enamel organ.
2. Follicular odontoma
3. Fibrous odontoma
4. Cementoma
5. Compound follicular odontoma

(2–5: from the tooth follicle.)

6. Radicular odontoma: from the papilla.
7. Composite odontoma: from the whole germ.

His description of the epithelial odontoma identifies it with what is called by some cystic odontoma and by others adamantinoma, the latter term being applied to the tumor because of its origin from the enamel organ. Besides these more common terms, many other names have been given to this type. Bland-Sutton believes that many tumors of the jaw reported as belonging to this group are really endotheliomata. He also asserts that the term dentigerous cyst should be replaced by that of follicular odontoma.

Scudder (3) defines an odontoma as "a tumor of the jaw arising from a portion of a tooth's follicle." He uses the term follicle to include the dental epithelium or enamel organ, the dentine papilla, and the enveloping connective-tissue sac; that is, the whole tooth-germ. Other writers use the term follicle, at least from the standpoint of its connection with tumors, as synonymous with the third element only; that is, the fibrous sac enveloping the enamel organ and papilla.

Scudder regards Bland-Sutton's classification as best but as including too many varieties for the convenience of the surgeon. He discusses the following as being of surgical importance:

1. Dental root cyst.
2. Follicular or dentigerous cyst.
3. Compound or composite follicular cyst.
4. Adamantine epithelioma.
5. Hard odontomata.

The use of the last mentioned group (5) is believed to simplify the naming of these tumors and probably does from the surgical standpoint; histologically it is quite indefinite. Scudder's description of the gross and microscopic structure of these five groups is in general quite satisfactory and his discussion of the embryology of the teeth, explained by many illustrations, is very clear.

Blessing (4) distinguishes between the adamantinoma and odontomata. He traces the origin of the latter from ectopic tissue between the tooth site and the mouth epithelium and says odontomata are tumors whose structure resembles dentine. His discussion of the subject is of little value.

New (5), in reporting 26 cases from the Mayo clinic, divides cystic odontomata into two groups: the simple cysts and the adamantinomata. The simple cysts are of two types: (A) those commonly called dental or root cysts; (B) those usually called follicular cysts. The term follicular cysts for the second type he regards as misleading because it implies, although not necessarily, that the cyst has developed from the follicle of a tooth. He considers that the term dentigerous cyst is used too loosely and does not employ it. His cases include 12 of type A, 6 of type B, and 8 adamantinomata. The discussion of New's paper showed there was no unanimity of opinion as to the value of his classification of the epithelial group of these tumors.

Hopewell-Smith (6) adds the term "odontocele" to the many names already employed, distinguishing between "extracapsular" and "subcapsular" types. Those who discussed his paper were almost unanimous in the belief that new terms only add to the present confusion. Most thought dentigerous cyst a better term than odontocele. Bennett regarded the description of the extracapsular odontocele as identifying it with a typical follicular odontoma.

In 1910, L'Esperance (7) reported 8 cases of adamantinoma from the Pathological Laboratory of Cornell University. In that laboratory they divided these tumors, according to the type and arrangement of the epithelial cells, into three groups: (1) acanthomatoid; (2) plexiform; (3) glandular. I can see only confusion resulting from the attempt to distinguish every individual peculiarity of a tumor by a separate name. It possibly had justification in this instance in connection with a feature emphasized by Dr. L'Esperance, and in the discussion by Drs. Ewing and Kelly, namely, the metaplasia found in recurring tumors of this kind. One of their cases thus furnished 5 specimens, the diagnosis in some being in doubt and the histology ranging from that of epithelioma to spindle-cell sarcoma and perithelioma. This feature may underlie Bland-Sutton's opinion that many endotheliomata have been called odontomata. Ewing characterized the metaplasia in these tumors as unusual and a fact that must be recognized if one is to be a safe diagnostician in such cases. He again refers to this case in a recent discussion of tumor transformation in experimental cancer research (8).

Mallory (9), following his method of naming tumors, speaks of tumors of the enamel organ as adamantoblastomata. He recognizes three types of tumors arising from the enamel organ: (1) the follicular cyst; (2) the adamantinoma; (3) no distinct italicized name as in the first two is given for the third type; the statement is made that the adamantinoma occasionally produces typical enamel but more often converts adjoining fibroblasts into odontoblasts, producing separate or fused teeth (odontoblastoma). This third type of Mallory, I do not understand. Odontoblasts are the superficial cells of the papilla, or connective-tissue portion of the tooth, and produce dentine; why this process should be discussed as a type of tumor arising from the enamel organ is not clear.

In addition to the cysts forming in the enamel pulp of adamantinomata, Mallory describes cysts, which may be more numerous and larger, that develop in the connective tissue of the stroma as the result of focal collections of fluid. In the latter type the nuclei of the epithelial cells are in the portion of the cell farthest from the cyst, in the former they are nearest the cyst cavity.

Dean (10), in reporting a compound follicular odontoma of the superior maxilla in a girl of 20, accepts the classification of Bland-Sutton.

Bland-Sutton (11) reports a case of radicular odontoma in the lower jaw of a man of 62; this he emphasizes as an unusual age. He states that odontomata have been so carefully studied that they are now the most complete tumor group known to pathologists. This may be true as a general statement but certainly does not appear to be so as to details and classification.

Stumpf (12) in 1910 reported an adamantinoma of the upper jaw and refers to several others that had been reported, although these tumors are much more common in the lower jaw. His is the first case in German literature in which the growth extended into the antrum of Highmore; it also involved the nose. He states that one can speak of solid, cystic, and multilocular adamantinomata. The solid represents an early, the cystic a later stage of the growth. The multilocular is also solid in the early part of its course.

Lewis (13) reports three cases of "multilocular cysts of the jaws." One tumor was the size of an orange with most of its septa entirely fibrous, a plate of bone being only occasionally present. A second tumor contained neither bone nor cartilage in the sections examined.

Fischer (14) reports what he regards as a primary adamantinoma of the tibia in a man of 37. Swelling appeared four months after he had fallen and struck the tibia on the edge of a stair. The tumor was the size of a hen's egg. Resection of 8.5 centimeters of the tibia, with bone implantation, was performed. Fischer furnishes many illustrations to show that the tumor arose from misplaced rests of enamel organ. The findings were entirely against its being a metastasis of a jaw tumor. The possibility of its being an endothelioma is discussed by Fischer and excluded.

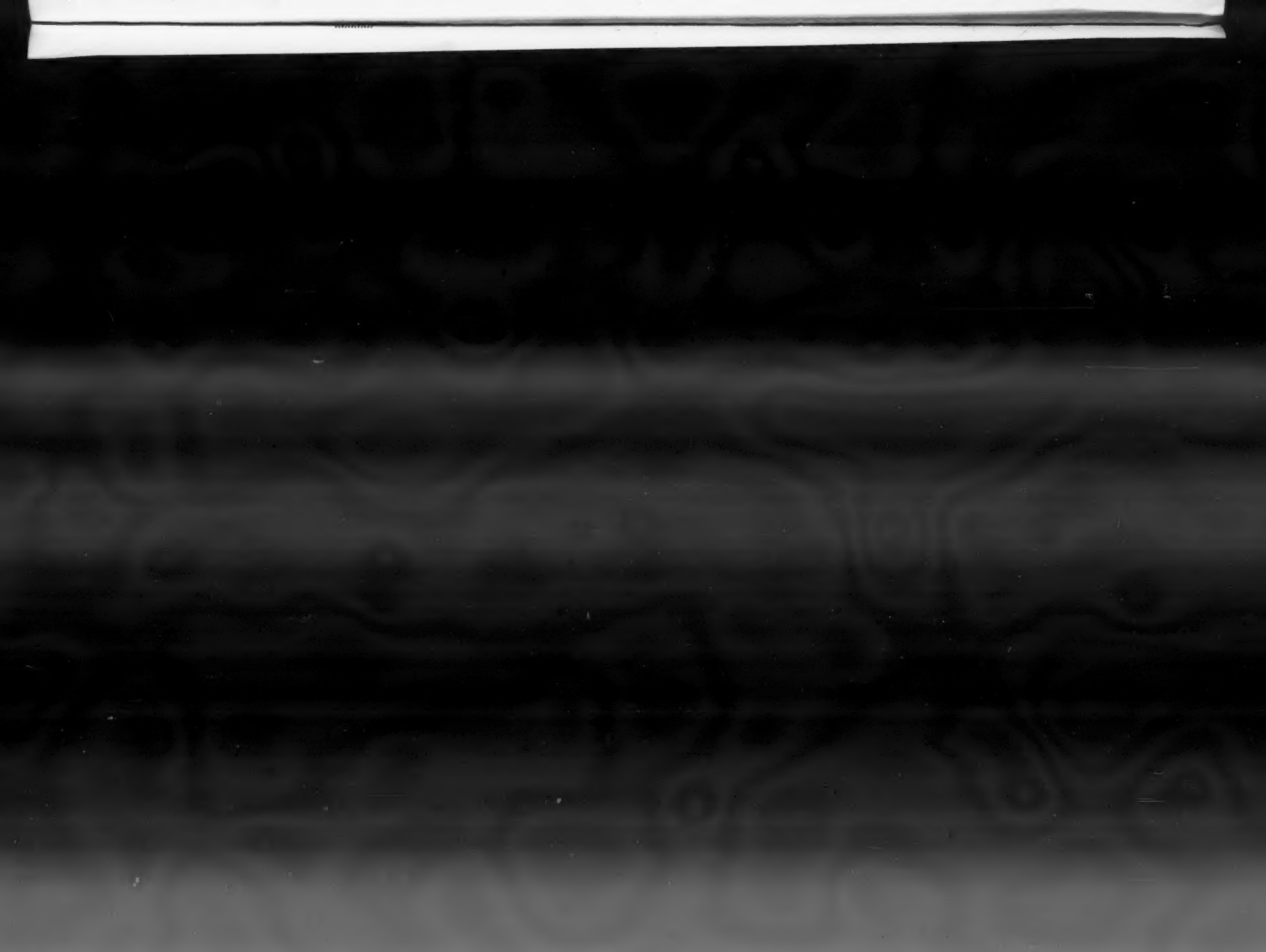
If this tumor were really an adamantinoma it would seem to be unique in literature. Many if not all of the adamantinomata of the jaws are supposed to arise from retained rests of the enamel organ, the paradental epithelial débris of Malassez, near the teeth. I do not know of a case other than that of Fischer in which they have been supposed to occur in other parts of the body.

The most carefully considered and elaborate discussion of odontomata is that of Messrs. Gabell, James, and Payne, a Committee appointed in 1907 by the British Dental Association to consider these tumors. Their report (1), published in 1914, contains the clinical and pathological description of scores of tumors collected as a display at one of the meetings of the association. The committee finally adopted a classification based upon, but considerably modifying, that of Bland-Sutton. Because of the limited circulation of this report, the classification of the committee, with general descriptive points, is here given in full. (The Committee uses throughout the term "odontome" instead of odontoma).

1. *Epithelial odontomes.* Where the abnormal development takes place in the dental epithelium alone:
   - Multilocular cysts
   - Dentigerous cysts
   - Dental cysts
2. *Composite odontomes.* Where the abnormal development takes place primarily in the dental epithelium and secondarily in the dental papilla, and may occur in the follicle also.
   - a. Where the abnormal development of the dental epithelium is such that the formation of numerous irregular dentine papillæ results, which are calcified in one mass or sporadically:
     - Complex composite odontomes
     - Compound composite odontomes
   - b. Where the abnormal development of the dental epithelium is such that the formation of two or more toothlike dentine papillæ results and are calcified as one mass:
     - Geminated composite odontomes
     - Gestant composite odontomes
     - Enamel nodules
   - c. Where the abnormal development of the dental epithelium is such, that the formation of a dilated portion of the dentine papilla results and is calcified as one mass:
     - Dilated composite odontomes
3. *Connective tissue odontomes.* Where the abnormal development takes place in the dental tissues of mesoblastic origin alone:
   - Fibrous odontomes
   - Cementomes

This classification, like all others, is of course open to criticism and objection. A very instructive discussion of it is given editorially in the *British Medical Journal* (16). With its descriptive statements, this method of division forms an admirable basis for a study of the real nature of these tumors, even if one does not entirely agree with the naming of the varieties. The report as a whole, with the descriptions of the many tumors included and the numerous illustrations, is a most valuable addition to the literature on odontomata.

The various methods of classification here reviewed show something of the different views held as to the naming of these tumors. A summary of the subject, especially including details of the epithelial group, can best be given after consideration of the specimens forming the basis of this paper.



The larger of the two tumors furnished me by Dr. Bonney was an irregular, dark reddish mass of tissue 2 by 3 centimeters; accompanying this main part of the tumor was a very thin plate of bony tissue 3 centimeters wide and several very small fragments resembling the larger mass. In the largest piece, on section, could be seen several small cysts. The clinical diagnosis was cystic odontoma.

Microscopically the coarse stroma of the tumor is largely of osteoid tissue. This is in bands of varying width and at points are lamellæ suggestive of haversian systems. In places are broad bands of connective tissue in addition to, or instead of, the osteoid structure.

Between the stroma-like masses of osteoid tissue are islands of dense or moderately cellular connective tissue in which are nests or cords of epithelial cells (Fig. 1). The peripheral layer, next the enclosing stroma, of many of these cell-masses is cylindric in type. These cells have round or oval nuclei placed nearer the inner than the outer extremity of the cell (Fig. 2). In some instances the peripheral layer is less tall and the nuclei do not have the polar position. The central part of each small cell mass is made up of round or moderately elongated cells. In the larger and evidently older cell collections, a distinct change takes place in the central cells. Many of them are elongated or actually flattened in shape, the cytoplasm is more abundant and slightly basophilic in reaction. Between many of these cells, especially those not so markedly elongated, are cytoplasmic bridges, giving a stellate outline to the cells and forming a network between them. (This is particularly characteristic of the enamel organ.)

In a more advanced stage the flattened cells assume a concentric arrangement, giving in some instances a striking resemblance to the pearls seen in epidermoid cancers (Fig. 3). The cells in the center of these concentric masses, or even where that arrangement is not pronounced, become less prominent, stain less deeply, seem to fuse, and finally reach an advanced stage of granular degeneration and disintegration (Fig. 4). As a result of this there are formed small spaces, either

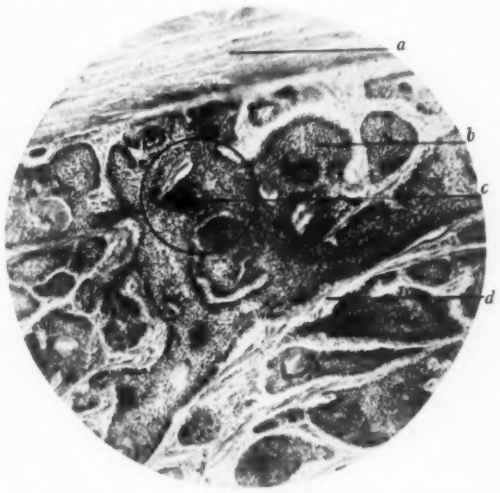


Fig. 1. Portion of odontoma under low magnification to show general structure of tumor. *a*, Dense connective tissue bordering growth; *b*, groups of epithelial cells resembling more or less closely the enamel organ; *c*, one of the pearl-like masses of degenerated epithelial cells (area within circle shown by higher magnification in Fig. 3.); *d*, connective-tissue stroma.

empty or partly filled by granular débris, these being bordered by the elongated or flattened cells previously described (Figs. 5 and 1). As the spaces become larger and assume actual cyst form, these flattened cells are crowded against the peripheral columnar layer, the two together forming the wall of the cyst (Figs. 6 and 7). In some of the larger cysts this flattened cell layer becomes extremely thin or disappears but none of the cysts I have seen lacks entirely the peripheral columnar layer. (New describes its disappearance in large cysts.)

Most of the individual cell masses and cysts are surrounded by a narrow zone of connective tissue, more dense than that of the intervening portion. In isolated areas of the connective tissue are small hæmorrhages, unaccompanied by necrosis. The mucosa of the gum, where present over the tumor, is intact.

In addition to this tumor Dr. Bonney had previously given me a small piece of tissue, 1.5 centimeters long, as a specimen of dental cyst. The general structure of this tumor is essentially the same as that of the one described, although no osteoid tissue is found

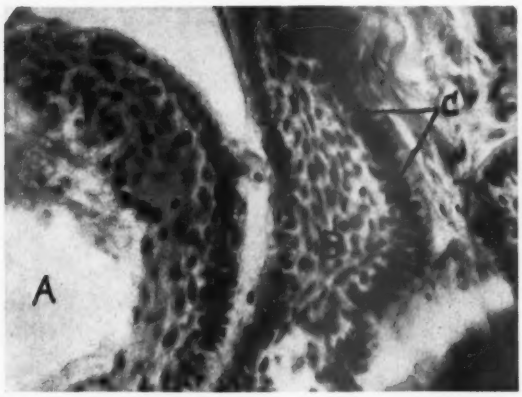


Fig. 2. Portion of cyst-wall and neighboring epithelial strand. (Higher magnification of part within circle in Fig. 5). *A*, Cavity of cyst with wall to right; *B*, strand of epithelial cells resembling enamel organ; *C*, adamantoblasts (ameloblasts). Nuclei at inner poles of the cylindric cells, farthest from the bordering connective tissue.

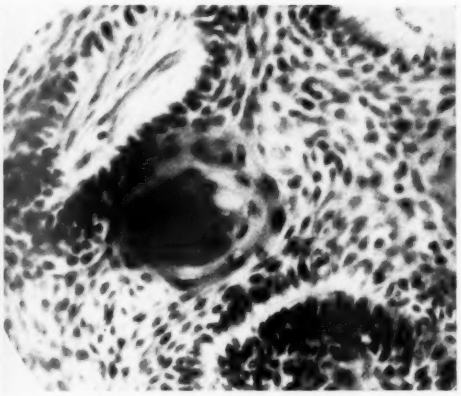


Fig. 3. Mass of concentrically arranged, flattened, degenerated epithelial cells resembling "pearls" in epitheliomata. This change precedes cyst formation. (Higher magnification of part within circle in Fig. 1.)

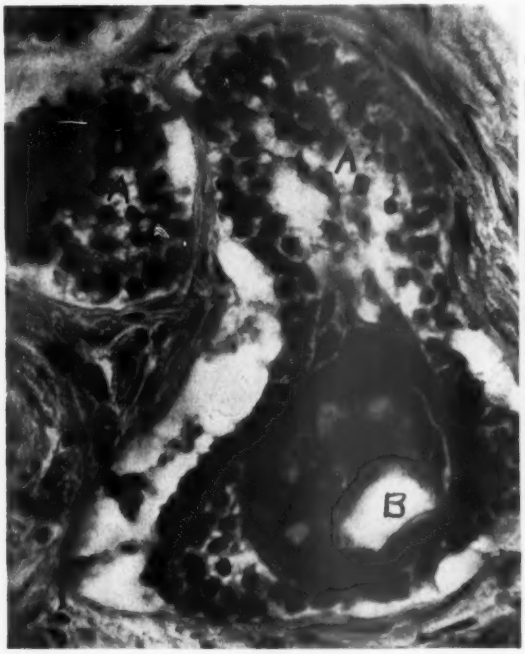


Fig. 4. Masses of epithelial cells showing *A*, *A*, stellate central cells; *B*, degenerated cells in which cyst formation has just begun.

Fig. 5. Area of tumor in which cyst formation (*A*) is farther advanced than in Fig. 4. (Part in circle is shown under higher magnification in Fig. 2.)

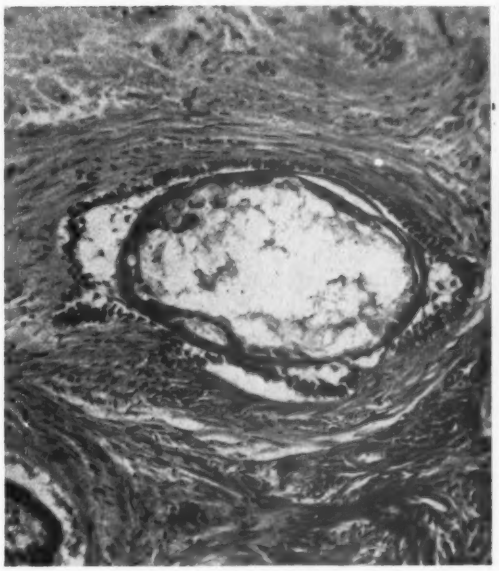


Fig. 6. Well advanced cyst. The cavity is partly filled by granular débris. It is bordered by a thin layer of extremely flattened cells which for a part of the circumference are in contact with the outer columnar layer.

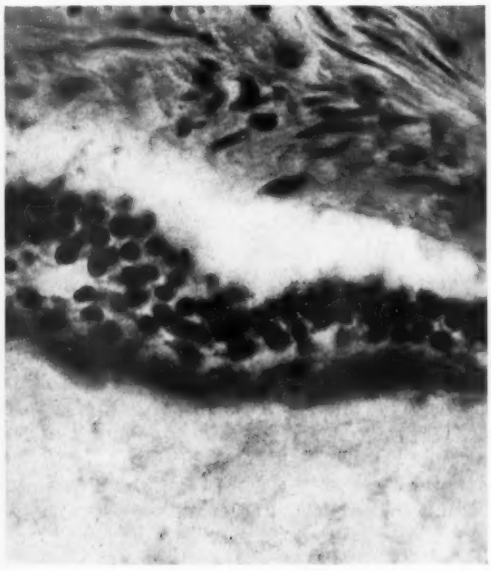


Fig. 7. Higher magnification of the wall of a cyst similar to that shown in Fig. 6. The cavity of the cyst, containing granular débris, forms the lower part of the figure. Above this are the flattened cells, just within the external layer of columnar or cuboidal cells.

in the septa. The stroma consists simply of bands of connective tissue variable in width, mostly rather narrow. The peripheral layers of epithelial cells are columnar but not so many of them distinctly of the adamantoblastic type as in the first specimen. Concentric arrangement of cells is in places well marked. Cyst formation has occurred, some of them being larger than those in the other specimen. At points the peripheral cell masses have an appearance and a relation to the surrounding connective tissue very suggestive of carcinomatous infiltration.

These two tumors therefore very clearly belong to the same group; epithelial odontomata. They well illustrate the difficulty in deciding upon the exact type of the tumor by the gross appearance, one being sent to the laboratory as a cystic odontoma, the other as a dental cyst. According to the classification of the British Dental Association both specimens should have been called multilocular cysts, as they do not use the term cystic odontoma. Neither do they employ the term adamantinoma, as used by New and many others to designate tumors of this type; namely, those formed from the enamel organ. If this name be employed, both our specimens are adamantinomata.

Combining the lists of synonyms given by various writers, we have the following names that have been used for tumors possessing the structure described: epithelial odontoma, cystic epithelioma, multilocular cystic epithelial tumor, adamantine epithelial tumor, adamantinoma, adamantoblastoma, cystic carcinoma, adenocarcinoma, adenosarcoma, multilocular dentigerous cyst, cystadenoma of jaw, fibrocystic tumor of jaw, cystic sarcoma, cystic adenoma, proliferating follicular cystoma. Of the adamantinoma, these subvarieties to indicate individual peculiarities have been named: solid, cystic, multilocular, acanthomatoid, plexiform, glandular.

The classification of odontomata as adopted by the British Dental Association is probably the best, but it differs in two respects from that of many other writers. First, it does

not use the term adamantinoma, and second, it retains the term dentigerous cyst. Instead of adamantinoma, the association employs the term multilocular cyst, defining it as "an innocent tumor arising from the dental epithelium with the formation of numerous cystic cavities." They do not speak of the precystic stage, which Stumpf designates solid adamantinoma. Dentigerous cysts they describe as "innocent cystic tumors arising from the dental epithelium and connected with unerupted teeth," and state that these cysts are also called follicular odontomata and cystic follicular odontomata. Dental cysts are "innocent simple cystic tumors arising, as the result of irritation, from the dental epithelium about the root of a tooth which has undergone eruption." The division of the epithelial odontomata into multilocular, dentigerous, and dental cysts is as simple and satisfactory as any that has been made. It has the advantage of giving the odontomata the same term, *cysts*, and emphasizes one of their chief characteristics, for although the first named may not be cystic from the very beginning, it rapidly and certainly becomes so. Again, the three types of cyst make a logical division of, and an improvement upon, the group name *cystic odontoma*, a somewhat indefinite term which is often used. Personally, I believe that the term adamantinoma would be more appropriate for some of the more complex tumors of other groups in which enamel is a common finding than it is for these cystic growths in which it is rarely if ever found. (Scudder quotes Chibret as describing the formation both of enamel and cementodental tissue in a tumor of this type, but the presence of the latter elements remove it from the pure epithelial tumors and hence from the adamantinomata). Of course, this statement can be met with the one that adamantinoma is used to designate a tumor derived from the enamel organ and not a tumor enamel-like in consistency. Notwithstanding, there appears something more logical in the division of epithelial odontomata into the three types of cyst than into other dissimilar-named varieties, as New's, into two types of cyst and adamantinoma.

These tumors occur more frequently in women than in men, and much more often in the lower than in the upper jaw, eleven to one according to some writers. They may occur at any age and usually grow slowly, some having a duration of 20 years or more. The size is extremely variable.

An important point is the question of malignancy. Odontomata of all types are listed as benign tumors but individual cases are possibly exceptions. Some cysts reform if a portion of the wall be left at operation, as in Case 1, but this is not necessarily an evidence of malignancy. The British Committee came to the conclusion that the so-called malignant odontomata do not possess the essential characters of malignant tumors, and that a new group, "malignant odontomata," is not at present warranted. Theoretically malignancy is possible and they state that if the case reported by Eve (15) be correctly attributed to dental origin, it would be an exception to the rule of benign tumors. The previously mentioned case of Ewing, with its four recurrences, possessed one of the attributes of malignancy, but its metaplasia into a connective-tissue type made it more than the ordinary odontoma. Metastases apparently do not occur.

For the photomicrographs we are indebted to Dr. W. M. L. Coplin.

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TUBERCULAR CERVICAL ADENITIS IN CHILDREN

By W. E. LADD, M.D., F.A.C.S., Boston

As the result of clinical experience, bacteriological and pathological research combined with comprehensive studies of the occurrence and spread of the disease, tuberculous cervical adenitis has become one of the best defined affections of childhood. Among the non-contagious diseases of children, the high occurrence of the affection and its sectional prevalence have been factors precipitating far-reaching investigations upon etiology and prevention, such as the great Edinburgh report, toward which Mitchell, Woodhead, Delepine, Stiles, Raw, and others contributed classical studies.

Very few American writers have driven home the fact of occurrence with the same emphasis as the foreign investigators. In considering the prevalence of tuberculous glands among children, few realize the predominance of this form of tuberculosis. At the Sixth International Tuberculosis Congress, Karlson of Stockholm, reported from the examination of more than fifteen thousand school children, that nearly ten thousand had early glands, and of this number from 10 to 30 per cent had definite or present tuberculous glands. On the other hand, only 1.60 per cent of the children had lung tuberculosis, and those with bone and joint affections were but 0.57 per cent.

Raw finds that in countries where cow's milk is not drunk, surgical tuberculosis does not exist, though phthisis is common, and considers that tuberculosis from the bovine and human bacillus are of perfectly distinct and different types. How the figures in this community would compare with those of Karlson, I do not know, but it is certain that tubercular adenitis is much more common in children than adults, and that the glandular infections are probably more common than the pulmonary in children.

The probability of most of these being of bovine origin has awakened the public to the advisability of a non-tubercular milk supply. To universally procure such, still requires plenty of work on the part of the medical man and hygienist in co-operation with the boards of health and legislatures. In the meantime, treatment and the end-results to be expected from surgery are perhaps the most important aspects of the disease.

To the most effective surgical treatment, an early diagnosis of tuberculous glands is of great importance, and except to the physician of considerable experience, early diagnosis presents certain difficulties in differentiation from other cervical lesions of somewhat similar appearance.

Tuberculous cervical adenitis is always secondary to some portal of entry; the commonest of which is the tonsil, those of rarer occurrence being the adenoid, tooth, ear, or skin of the face or scalp. The appearance of the primary focus may be useful as an aid to diagnosis, when such a focus occurs in the skin. For instance, the characteristic appearance of the lupus, makes it logical to conclude that the enlargement of glands draining this area is of a tuberculous character also.

The portal of entry, however, is rarely such a landmark and by far the commoner method of arriving at the diagnosis is to draw conclusions based upon experience of the general symptoms, signs, and appearance of the glandular swelling, and then from one's knowledge of the distribution of the lymph-vessels, conclude what is the portal of entry. Glands lying closely under the body of the jaw in which there is a carious tooth, point very conclusively to the tooth as the portal of entry, but the surgeon is dependent upon the feel, appearance, and action of the glands for his diagnosis of tuberculosis and not on any peculiarity of the carious tooth. In the vast majority of cases which one sees, the glands affected are those under the angle of the jaw, the glands which drain the tonsil, but here again the diagnosis must be made from the glands. The tonsil has no gross appearance upon

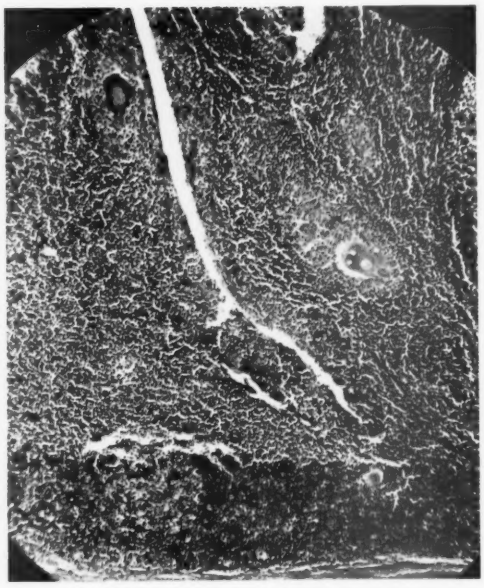

Fig. A. A tonsil removed from one of the writer's cases of tuberculous adenitis, showing a crypt with a tubercle on either side deep in the tonsil-tissue.

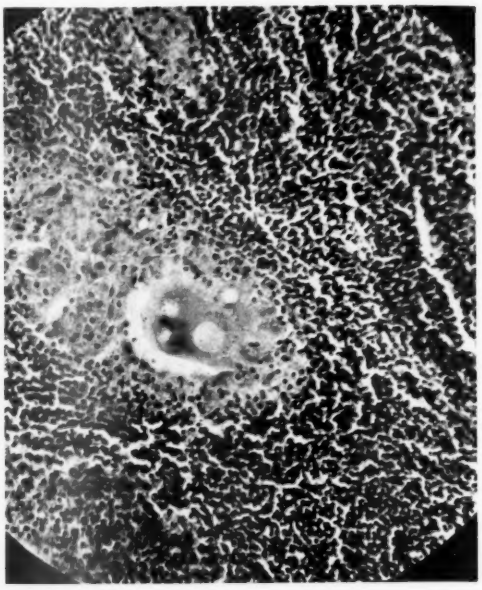

Fig. C. The other tubercle shown in Fig. A under higher magnification, slightly more advanced and further removed from the crypt.

which the diagnosis of tuberculosis can be made. This fact was demonstrated two years ago in a study of the tonsils as the major portal in my own cases, which was undertaken with Dr. Karsner. Histological examination showed the presence of tubercles in the tonsils which could not be diagnosed as tuberculous from clinical examination of the throat. The distribution of tubercles as seen in the accompanying microphotographs (Figs. A, B, and C) suggests strongly that the tubercle bacilli gain entrance to the tonsil through the crypts, and also shows from the proximity of the tubercles to the capsule the necessity of removing the capsule with the tonsil, if one wishes to eradicate the disease. I have had demonstrated with the microscope tubercles in tonsils of the large, protruding type, as well as in those buried in the fauces, and believe it is as impossible to tell which tonsil may be harboring tubercles from inspection, as it is manifestly impossible to see the tubercles themselves. Tuberculous ulcer of the tonsil is an entirely different pathological condition, and one which I have never seen associated with tuberculous cervical adenitis in childhood.

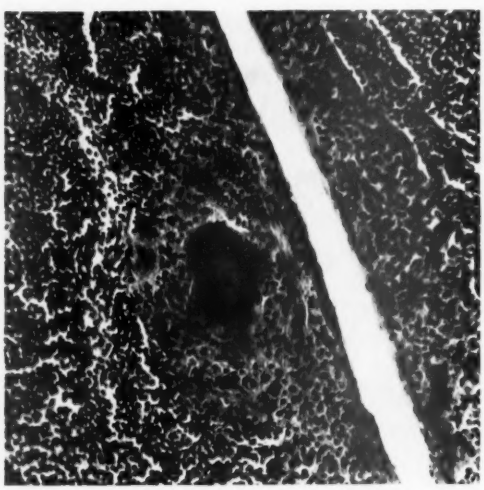

Fig. B. Larger magnification of same case as Fig. A, showing the giant and epithelioid cells characteristic of tubercles and the close proximity to the crypt.

Fig. 1. Early tuberculous cervical adenitis.
Fig. 2. Same case as Fig. 1, after removal of glands. Note the inconspicuous scar.

Fig. 3. Inconspicuous scar following removal of tuberculous glands at an advantageous time.
Fig. 4. Same as Fig. 3, to show how scar cannot be seen from in front.

Tuberculous glands of the neck in the early stages are discrete, freely movable, and lack any of the local or general characteristics of acute inflammation. The pat ents as a rule have no elevation of temperature, and other than a characteristic placid appearance, easier to recognize by one who has seen a large number of these cases, than to describe, show no general manifestations of the disease. In this early stage, when the gland under the angle of the jaw has attained the size of a filbert, or is perhaps still smaller, a negative von Pirquet reaction is of value in ruling out tuberculosis. A positive von Pirquet is of little or no value, as such a large proportion of children give positive reactions anyway. Failure of the glands to disappear following tonsillectomy is a positive indication of their being tuberculous in nature, or at least something more than simple chronic hypertrophy. Figure 1 shows a tuberculous adenitis in its early stage when the diagnosis should be made and when the removal of the glands can be performed with confidence as to a permanent cure and with a very inconspicuous scar. (See Figs. 2, 3, and 4.)

The infected glands, untreated, increase in size and number in an irregular manner. They may enlarge rather rapidly for a week or two, then remain quiescent or even decrease sometimes for quite a long period of time, on!y to increase again later. The most superficial gland usually increases more rapidly than those underlying it, and frequently becomes adherent to the skin and the underlying glands. Later groups of glands coalesce, forming large irregular masses (see Fig. 5), the most superficial part of which may be fluctuant, while the deeper parts remain hard and nodular, the whole presenting a very characteristic appearance resembling no other condition closely. Rarely, the glands break into one another, forming a large mass, the whole being surrounded by a dense fibrous capsule (see Figs. 7 and 8), and allowing one to remove the whole *en masse*. Such cases resemble sarcoma more closely than the commoner variety of adenitis, but the course of the disease is quite different. The sarcoma develops more rapidly and more regularly, has on palpation a firmer and more solid feel, and when it has reached a large size frequently becomes marked by prominent superficial veins.

The glands of Hodgkin's disease, though sometimes limited to one side of the neck at the start, usually soon become more general in distribution, involving both sides of the neck, the axillæ, and groins. Hodgkin's glands remain discrete, not coalescing even when attaining very large proportions, and do not become fixed or adherent from periglandular inflammation.

Enlarged glands of syphilitic origin are of rare occurrence in children, and can be distinguished by other manifestations of the disease. Branchial cysts, or thyroglossal

Fig. 5. Advanced tuberculous adenitis. Most superficial gland broken down. Others still hard.

Fig. 6. Same case as Fig. 5, after removal of glands. Note how much more conspicuous vertical scar is than transverse.

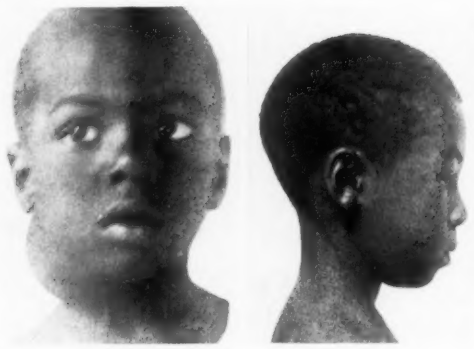

Fig. 7. Large encapsulated mass of tuberculous glands.

Fig. 8. Same case as Fig. 7, to show how a large mass can be removed leaving a small scar.

ducts, occasionally have to be considered in the diagnosis, but their anatomical situation, their occurring singly and their appearance usually makes them easy to differentiate.

The time at which operation should be performed is of such importance that the more difficult diagnosis should be left to the surgeon whom experience has trained to make definite associations between the conditions bared at operation and the clinical examination.

For tubercular glands arising from the skin of the face or scalp, from the ear, tooth, or nose, a special operation is required for each individual case, according to the position of glands and the amount of involvement. But a very large majority of the cases seen have the tonsil for the portal of entry and involve the glands under the angle of the jaw first. For this typical group of cases the tonsils should always be removed and in very early cases if there is doubt about the diagnosis, the glands may be left alone for a short time until the diagnosis is established. Care should be taken, however, not to wait long enough for the glands to break down and result in abscess which increases the difficulty of operation and endangers the good results.

In typical cases involving the glands, draining the tonsils, the operative technique here is quite similar to that employed by Dowd.[1] A transverse skin incision is made in one of the natural folds of the neck, one or two fingers' breadths below the body of the jaw, and extending from the posterior border of the sternomastoid muscle, as far forward as need be. The length of the incision is dependent upon the size of the glands to be removed. After incising the skin, the platysma muscle is cut across, the anterior border of the sternomastoid identified and the glands exposed in the superior carotid triangle. The most superficial gland usually shows more advanced caseation and liquefaction than those underlying it, and care should be taken to avoid rupturing it. But if a nick is made in it and some caseous pus spilled, it does not mean that the dissection should be necessarily abandoned; the pus may be sponged out with dry gauze, the wound wiped with tincture of iodine, and the dissection continued. All layers of the upper side of the wound to the deep cervical fascia are now retracted upward, including in the retraction the lowest branch of the facial nerve and the dissection is carried inward until the posterior belly of the digastric muscle comes into view. The anterior border of the mass of glands is freed until the facial or internal jugular vein is exposed. The glands are then retracted backward and loosened by blunt dissection until the spinal accessory nerve is identified and exposed to its point of entrance into the sternomastoid

[1] Ann. Surg., Phila., 1908, Aug.

muscle. This group of glands are now removed, leaving in view in the wound the anterior border of the sternomastoid, the posterior belly of the digastric, the facial and internal jugular veins, and the spinal accessory nerve. The group of glands lying behind the spinal accessory nerve and sternomastoid muscle are next removed, and then those following the course of the internal jugular vein. In cases where the dissection is very difficult and the glandular involvement very extensive, a second incision may be made below and parallel to the first, or a vertical incision behind the sternomastoid joining the posterior end of the first incision (see Fig. 6). Such procedures, however, are necessary only in neglected cases which come to the surgeon late. All visible and palpable glands having been removed, a small opening is made behind the sternomastoid for drainage, the wound is wiped out with half-strength tincture of iodine and the incision closed by suturing the platysma with interrupted catgut and the skin with intracuticular silkworm-gut suture. If the patient's condition warrants it at the end of the dissection in the neck, if the tonsils and adenoids have not already been removed, they are now enucleated. If at the end of the dissection the patient's condition does not warrant a tonsillectomy, this may be performed two weeks or so later. It has been said that removal of the tonsils at the same sitting as glands of the neck prevents primary union of the wound, but this has not been my experience, practically all cases operated on at an advantageous time healing *per primam*. In cases where the glands have broken down so far as to form an abscess, and where the periglandular inflammation is so marked as to obliterate all lines of cleavage, a dissection is out of the question. In such cases a comparatively small incision should be made, the cavity curetted of as much necrotic material as safe, and then wiped out with tincture of iodine. This procedure is curative only for those cases of superficial abscess without underlying glands, a condition occurring rather rarely. For the cases with underlying glands, the incision, curetting and drainage of abscesses results in sinus formation, the glands beneath breaking down one after another and keeping up the discharge sometimes for months or even for years, unless further operative treatment is instituted. When a sinus has reached a comparatively quiescent stage, it is safe and advisable to excise it and dissect out the glands beneath, which will effect a cure. The wounds resulting from operations performed under these conditions heal by first intention surprisingly often, and when they do not are practically always healed at the end of two or three weeks, a status far more desirable to both patient and surgeon than a discharging sinus for two or three years. The after-care consists in removing the small drain at the end of forty-eight hours, keeping the patient in bed for two or three days, and in the hospital about ten days; then providing nourishing food, a non-tubercular milk, outdoor life as much as possible, and in general good hygienic conditions.

During the past five years I have operated on 159 cases of tuberculous cervical adenitis at the Children's Hospital and in private practice. Of these the end-result has been ascertained at periods of time varying from six months to five years in 130 cases. Of the remaining 29 cases, two are dead, and 27 either have been lost track of or have been operated on too recently to make an opinion of the result valuable. Of the two deaths, one occurred six months after the operation in a child who had done very well and shown no evidence of either local or general recurrence of the tuberculosis, but who was taken with lobar pneumonia from which she died. This death cannot in any way be connected with the operation, or have any particular bearing on the fact that the child had had previously a tubercular adenitis. The other death occurred in a child in whom the diagnosis of meningeal tubercle with recovery had previously been made. She presented a large mass of broken down glands, and an attempt was made to dissect them out. She died three days after the operation with a very high temperature and meningeal symptoms. This operation was performed some four years ago, was probably ill-advised, and is the only operative death which has

occurred in this series of cases. In the other 130 cases, excision of all palpable glands, with two exceptions in which excision was somewhat limited by special conditions, was practiced 119 times, the results of which are considered later. Incision of tubercular abscesses followed by curetting and wiping the cavity out with gauze and tincture of iodine was the operative procedure 11 times. Of these eleven patients followed, 5 have been apparently cured, while 6 still presented evidence of active tuberculosis when last examined, and in them the following points are of interest and worth mentioning:

CASE 1. Tubercular adenitis of two years' duration, for which excision was advised. Child's condition under ether did not warrant a dissection, so incision, curetting of the glands, which were most broken down, was practiced. Sinus formation lasting for weeks followed; X-ray treatment tried. One year later number of glands present on both sides of neck. General condition poor.

CASE 2. Persistent glands for one year. General medical treatment for same period. Entered hospital with glands on both sides and abscess condition such that excision was inadvisable. Following incision operation, sinuses persisted for one year in spite of excellent hygienic treatment and X-ray treatments for six months. Further operation necessary for a cure.

CASE 3. Glands of nine months' duration. Tonsils and adenoids removed a year before entry. Sinus persisted eight weeks following incision, and a year and one-half later, glands still persisting. Further operation advisable.

CASE 4. Child three months. Both sides of neck involved and both sides incised. Tonsillectomy advised but not performed. Two years later child reported with considerable glandular involvement. Then lost track of.

CASE 5. Tubercular abscess discharging for five weeks. Tonsillectomy a year previously. Carious teeth present. Five months after incision sinus persisting. Advice about care of teeth not followed.

CASE 6. Glands of six months' duration. Followed usual course in spite of tuberculin treatment in good hands, and the best of hygienic treatment. Incision and curetting of tubercular abscesses. Small sinus six months later still persisting.

In the 119 cases in which excision of all palpable glands with the portal of entry was attempted, 111, or 93 per cent, have shown no palpable glands or evidence of tuberculosis at examinations made from one to five years after operation. In 95 the wound healed by primary union, giving an almost immediate as well as a permanent good result. The 24 cases in which union was secondary were without exception cases in which the tuberculous process was far advanced, and in which incision into abscesses had been restored to before excision was accepted by the parents or possible to the surgeon. In the majority of these cases, even, the wound was healed inside of three weeks.

Of the 8 cases in which palpable glands of significance appeared after operation, in 3 the glands were on the opposite side of the neck. One had the tonsil removed on the side of the original glandular involvement only, and the occurrence of glands on the opposite side requiring a second operation, might have been avoided had both tonsils been removed at the first operation. In one case in which an excision was performed on one side of the neck and an incision of the other, a recurrence or persistence exists on the incision side. In a third case, glands appeared on the opposite side of the neck, along with a tubercular keratitis. The persistence in 2 other cases is coincident with secondary union of the wound and other tuberculous lesions, one bony, the other glandular, in the groin. In 2 cases failure to remove the tonsils is probably responsible for the occurrence, or persistence, of the disease. In the 1 other case there is only a very small gland present, which probably has no clinical significance, but as there is a question of pulmonary involvement, it has not been classed among the apparent cures.

From analysis of these cases, it is seen that failures of cure can usually be attributed to failure to remove all tuberculous tissue or to overlooking the portal of entry. Sometimes that is the fault of the surgeon's judgment in not recognizing the importance of the primary focus, and sometimes it is the fault of the parent or medical adviser in not recommending operation at a time when it is feasible to perform a clean dissection. The percentage of these failures is, however, small, and in marked contrast to the results to be expected from incision and drainage operations. Though in this series of cases but 11 results from the incision operation have

been presented, 41 of the dissection cases had had one or more palliative operations before being referred to me for excision. These cases have given ample opportunity for observation of the conditions following palliative operations, and have clearly demonstrated the undesirability of postponing surgical intervention until abscess drainage becomes a necessary preparation for an excision operation.

In 34 patients having persistent sinuses coming for radical operation, the duration of the unsuccessful treatment varied from one month to more than four years. In 2 the sinuses had persisted for thirteen and twelve months respectively, in spite of tuberculin and hygienic treatment. In 3 the sinuses persisted for thirteen, eleven, and six months, in spite of tuberculin and X-ray treatment in the first, and X-ray treatment alone in the other 2. The other 29 cases had had one or more incisions and some of them had excellent out-door hygienic treatment as well. The average duration of the sinuses in those 34 cases was ten and one-half months before the operation for removal of the glands was performed. How much longer the sinuses would have persisted without the more radical operation being performed, of course, it is impossible to say. Likewise it is difficult to tell how many of these patients would have eventually recovered or in how many the disease would have gone to other parts of the body. Probably many of them would have eventually recovered but only after a long and tiresome siege of frequent dressings.

CONCLUSIONS

From study of the literature and from my own experience, the following conclusions seem justified: That tuberculous cervical adenitis is a very common affection of childhood. That further investigations should be undertaken to establish more definitely the question of the disease originating from the bovine, or human, type of tubercle bacillus. That if it becomes firmly established that milk is responsible for the major number of the infections, it would seem possible to reduce greatly their frequency by securing non-tubercular milk supplies. That some children suffering from this disease recover by other forms of treatment than radical surgery, but only after long periods of time. That from my own experience and that of Dowd, and many other surgeons, radical operation, including the removal of the portal of entry, is by far the surest and safest method of obtaining a prompt and permanent cure. That when the operation is performed before the glandular involvement becomes very extensive, it need leave only a very inconspicuous scar. That over 90 per cent of cures resulting makes the operation one of the very satisfactory procedures of surgery.

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SYMPOSIUM ON EXPERIMENTAL SURGICAL STUDIES[1]

FROM THE DEPARTMENT OF SURGICAL RESEARCH, UNIVERSITY OF PENNSYLVANIA, SCHOOL OF MEDICINE

I. SURGICAL RESEARCH OF THE GREAT OMENTUM
II. RECENT EXPERIMENTAL STUDIES OF THE PANCREAS
III. TRANSPLANTATION OF THE URETERS INTO THE INTESTINES
IV. EXPERIMENTAL STUDIES IN COLONIC DILATATION

SURGICAL RESEARCH OF THE GREAT OMENTUM

BY S. L. BLOOMHARDT, C. F. ANDREWS, AND R. R. HETHERINGTON

THE great omentum has been the subject of medical interest and research for more than 3,600 years, yet, in this present era of scientific enlightenment, it is still an organ of much mystery. It has been worshiped and relied upon by the surgeons of the past and of the present, and it is our purpose in this paper to present you with data which we hope will lead surgeons to rely more upon it in the future.

Dr. John G. Clark, in his lectures, calls the omentum the policeman and the philanthropist of the abdomen. Dr. John B. Deaver says, to his mind, it is more like a fireman who hears the first alarm and hastens to the scene with the necessary means to smother the flames. It wraps itself around inflamed areas, protects against slow perforations, walls off purulent collections, and aids in absorption and exudation.

Thus you see the tribute the present day surgeons pay to this serous apron, and you wonder that during the whole of the nineteenth century so little attention was paid to it. There is a scanty literature on the pathological conditions of the organ, mainly on cysts and tumors of the same. This, with a few papers on its development, and still fewer upon sundry points of its histology, with practically nothing upon its physiology, represents, as nearly as we can ascertain, all that has been written during the past century. However, the inquiring minds of progressive surgeons, who explore many abdominal cavities, both physiologic and pathologic, along with the establishment of more modern research work, has forced a study of this important structure and brought to light many of the hidden functions and pathologic conditions of this hitherto neglected member.

And so, if following the time-honored custom, one wishes to lead gently up to the subject by referring to observations and conclusions of those who have gone before, he finds himself confronted by the fact, that with the exception of the past fifteen years there is little to be said unless he travels back through the centuries. So let us travel back to 3,600 years ago when we find that the cunning Egyptian priests told fortunes by the omentum; indeed it is most interesting to know that the organ was named by them. Priests, during the process of embalming the human body, would examine the abdominal viscera, and, as this organ in particular was a mystery to them, they used it for a gain and would tell fortunes by it, and, according to the purse that the relatives were able to pay, by examination of the omentum, would give either good or evil omen as to the hereafter of the dead. Thus the first part of the name (*omen*) and by adding the suffix *um* of the language, it came to be called the omentum.

When we pass back to the limits of medical history, strangely enough we find that old Hippocrates, 460–385 B.C., noted that which was more nearly correct than any observations for long centuries following. In addition to his aphorism, that if the omentum protrude, it necessarily mortifies and drops off, he makes a longer reference in his book, *περι τοπων*, which, did time permit, I would gladly read, because

[1] Presented before the ninth annual meeting of the Undergraduate Medical Association of the University of Pennsylvania, School of Medicine.

of its interesting nature and shrewd observations, but the abstract of it in a sentence is that he thought that the omentum regulated the amount of fluid in the peritoneal cavity.

After Hippocrates, we find that we owe to Aristotle, 384–322 B.C., the commonly accepted opinion that the omentum is formed of light membrane and so placed covering the intestines as to preserve the innate heat of the body. Galen accepted and expanded this view. He gives the case of a gladiator, who having lost his omentum through a wound, recovered from the injury but thereafter felt cold in his abdomen.

John Meckell, 1714–1744, practically exposed the nature, origin, and anatomy of the mesogastrium.

Malphigii, 1628–1694, considered the omentum as the cause of ascites and as a storehouse of fat. Other theories as to it being the cause of ascites followed, not worthy of note, simply mystic imagination. And, as in the writings concerning other organs in historic times, the omentum, as the rest, was made the text of numerous most wild discussions. For example, Fabricus (*ab Aquapendentii*), well known for his discovery of the circulation, held that it was the seat of those winds which so torture hypochondriacs. Cordeus taught that it was a second stomach, or food store, from which the stomach again received the food, when, by him, man was declared to ruminate, like unto brute beasts.

As to the anatomy, suffice it to say, that it is a serous membrane attached to the stomach and transverse colon, hanging apron-like from these structures. It consists of four layers of peritoneum, between which are found various structures: arteries, veins, lymphatics, nerves, fat, and fibrous tissue. Taking the liver as a starting point, the anterior layers of the omentum swing down in two folds until it reaches the stomach, where it divides, one layer going behind this organ and one in front. At the inferior aspect of the stomach the layers reunite and dip downward toward the pelvis, and then again swing to the transverse colon, thus forming the four layers.

To the naked eye the omentum is seen as a smooth and glistening membrane of peritoneum in which may be distinguished long slender blood-vessels. The larger arteries are always surrounded by fat, giving the omentum a fenestrated appearance.

Histologically, the omentum consists of a serous membrane. Except for a delicate layer of fibro-elastic tissue which supports the mesothelium, there is comparatively little framework, with the exception of the blood-vessels. This fibrillar structure is made up of a delicate network of curly strands of fibro-elastic tissue. The covering of the stroma consists of endothelial cells.

The arteries in the anterior leaflet of the omentum have their origin from the gastro-epiploic arteries. These dip downward in the anterior fold of the omentum and anastamose with those of the posterior leaflet which have their origin from the arteries of the colon. These vessels are extremely slender and send off numerous tree-like branches, usually almost at a right angle to the main trunk. The arteries are accompanied by veins. Many avascular areas are found, the tissue living by imbibition. These areas correspond to the clear spaces seen in the fresh specimen. They are scattered over the entire omentum and constitute from one-half to three-quarters of the free surface of the organ. In cases of peritonitis the smaller blood-vessels surrounding these areas become enlarged, numerous buds are thrown out, and in a very short time the previous avascular areas will be found to contain vast numbers of small vessels. These vessels play an important part in the combating of infection. While being extremely rich in blood-vessels, the omentum is nearly devoid of capillaries, there being a direct anastomosis between the veins and arteries.

In a general way it may be said that the chief lymph-channels follow the larger blood-vessels. The smaller vessels are found penetrating the omentum in all directions. On the surface there are openings which have some sphincter action, and they lead to underlying lymph-channels, thus showing one of the many most remarkable points about this organ. Numerous lymphatic glands are found at the upper border of the omentum. The omentum is well supplied with nerves. These nerves are derived chiefly from the

nerve-trunks of the stomach and transverse colon. Ganglia are also seen.

Concerning the physiology of this all-important viscus, there has been much work done, with a variance of opinions and results. However, this paper would not be complete without a brief mention of the functions and a short sketch of a little of the experimental work done upon it. First, concerning the movement. It has been claimed by many that the omentum has, in itself, the power of moving from one part of the peritoneal cavity to another, basing this assumption upon the well-known fact that the omentum is found adherent to inflamed structures, or even blocking ruptured typhoid ulcers, gunshot wounds, etc. Morrison likens this movement to that of a jelly fish. However, no muscular tissue has ever been demonstrated in the omentum, except that found in the walls of the blood-vessels, therefore, it is hard to conceive that it has any inherent powers of movement, but rather from its peculiar shape it is easily moved about by the action of the intestines and as the result of intra-abdominal pressure. Dr. Byron Robinson says it is like a floating cork in whirling eddies; the cork will finally float in the most quiet area, which in the case of the omentum is the focus of peritoneal infection.

It possesses a bodyguard of leucocytes which are ready at a moment's notice to move to a point of irritation to digest, imprison, or sterilize the invader. In fact Norris claims that the chief function of the omentum is one of leucocytogenesis, stating that he was lead to this view by a histological study rather than by the results of physiological experiments. Renzi and Boeri noted in experimental work that the omentum will nourish viscera which have become detached from their pedicles, finally absorbing these organs, stating that no other abdominal viscus possesses the protective or preserving powers of this organ. The omentum will successfully close apertures in both viscera and abdominal parietes. Many such cases are reported, two of which we have heard in our own surgical clinics this year, and did time permit it would be highly interesting to cite these cases. Dogs have been shot through the stomach with a 32 calibre bullet, and the omentum would sometimes close the bullet hole so effectually that the dogs, without surgical intervention, would be eating and playing within a week. It is a movable buffer or padding material, filling in temporary spaces in the abdomen. It is a peripheral lymph-regulating organ; however, it does not seem specialized for this function any more than the mesenteron. Numerous experiments on dogs, rabbits, guinea pigs, accompanied by careful microscopic examination, seem to prove that the omentum is not a special arbiter of peritoneal tides, but the function belongs more to the diaphragmatic peritoneum.

Thus you have heard a very brief sketch of the marvelous activities of this organ, some little of the experimental work done upon it, all of which goes together and raises the question in inquiring minds; since the omentum is so valuable physiologically — what could one do with it surgically? With this in view we started experimental surgical work on dogs. It has been observed in all abdominal experimental work, that practically every autopsy, two to six weeks after operation, showed omental adhesions to the wound of the visceral peritoneum, except wounds of the stomach. In Dr. Sweet's autopsies on dogs alone, omental adhesions to varying degrees have been observed in nearly 100 per cent of cases. Dr. Byron Robinson, Chicago, says: "Postoperative omental adhesions are always very numerous, as has been demonstrated in many cases, both in dog autopsies and on living and dead subjects." He found 75 per cent of subjects (both dog and man) presented postoperative omental adhesions either to the abdominal walls or to the point of operation on the viscera.

At the present day there is no known way of preventing adhesions and, since they cannot be avoided and do occur in a large percentage of cases, a logical procedure, it seems to follow, would be to use the omentum in such a manner that it would be of practical value. In fact, it should be borne in mind that the healing of wounds is essen-

tially a process of adhesion formation — a pouring out of lymph, the coagulation of the same and its later organization; therefore the absolute prevention of adhesion would likewise prevent wound healing.

Our first set of experiments consisted in taking different portions of the gastro-intestinal tract and making perforations in the same, then overlapping the great omentum, suturing it lightly to the gut wall. The immediate object being to find out in just what manner the perforation would be taken care of, if taken care of at all, how large a perforation we could make, and to observe if any untoward symptoms would develop, realizing that, if in repeated experiments the omentum would satisfactorily take care of these perforations, there are many surgical instances where it could be used. To make the perforations we used graduated cork borers. We took a series of three dogs, making perforations in both the jejunum and ileum, measuring from 1 to 2.6 cm. The omentum was folded 3 times over these perforations and sutured with silk. All the dogs made uneventful recoveries, evidencing no signs of peritonitis or obstruction. At autopsy, adhesions at the site of perforation were found; the wound of the mucosa showed more as a dimple than as a scar. Grossly, it is easy to recognize an overgrowth of mucosa covering the perforation. On the fourth dog we resorted to bolder measures, trimming away the gut with scissors until there was only about 1 cm. of intestinal wall remaining where the mesentery was attached. The length of the opening was 3.5 cm. In this instance the omentum was thrown clear around the gut and sutured, and then sutured to the edges of the perforation. The dog showed no signs of peritonitis whatever. At autopsy we found the omentum adherent to but one area of the gut, this corresponding to a defect in the mucosa which was linear and Y-shaped. There were no signs of peritonitis or obstruction.

The next experiment was done on the stomach, the perforation being made on the anterior wall of the antrum measuring 1.8 cm. This was covered with two layers of omentum held by a circular layer of stitches. The dog died the following morning from peritonitis. A defect was found in the covering of the omentum over the perforation, showing plainly an error of technique on our part, in not being sure of the placement of our sutures. We repeated the experiment in exactly the same manner. The marked peristalsis of the stomach tried again to force the opening out from beneath the omentum during the operation; hence it is reasonable to assume that this was the cause of the imperfect suturing in the preceding animal. This dog made a complete and uneventful recovery.

Following this we perforated the pyloric end of the stomach, making an opening of 2 cm. As before, this dog showed no ill effects of the procedure. Autopsy showed the omentum adherent to the site of the perforation and the interior of the gut presented a typical stellate scar.

We next assailed the colon; a perforation measuring 2 cm. was made. In this case we encountered two difficulties: the colon was distended with fæcal material, and the omentum was unusually small. The omentum was sutured over the perforation as before. The animal died that night of peritonitis and autopsy revealed imperfect closure of the hole by the omentum, fæcal material escaping at the lower pole, again showing a faulty technique on our part. We repeated the experiment on another dog. In this case the animal did not even become sick and made the usual uneventful recovery.

In the next set of experiments on five dogs, an end-to-end anastomosis was done, omitting the Lembert seroserous stitch and rapidly approximating the gut with through and through sutures, then placing the omentum around the wound, putting in several sutures through the mesentery to hold it in place. All five dogs made complete recoveries. Autopsies on these dogs showed a perfect anatomical anastamosis in each case. At the site of union the omentum was found wrapped around and adherent to the gut. In two instances adhesions were found between two adjacent loops of gut forming a broad U, with, however, not the slightest evidence of any obstruction.

The omentum, not having failed us thus far, we proceeded to place still greater burdens upon its shoulders. We cut off the blood supply to varying lengths of gut by ligation of the main mesenteric vessels and of the arcus intestinalis. Having done this we overlapped with omentum the area to which the vascular supply had been cut off. Our immediate object was to discover if the omentum would take care of a gangrenous area, if gangrene should ensue, or whether it would entirely prevent the occurrence of a gangrene. We took a series of four dogs, cutting off the blood supply from areas of gut varying in length from 6 to 16 cm. The omentum was doubled and placed around the gut, holding it in place by sutures through the mesentery only, that is, no omentum was sutured to the gut itself.

Following operation there were no signs of gangrene, intoxication, or peritonitis, all the dogs making complete recoveries. The autopsies showed extensive adhesions of the omentum around the gut, and upon opening into the lumen of the bowel absolutely no indication of damage could be found. Microscopically, no new blood-vessels could be demonstrated to have grown from the omentum to the gut. The existing omental vessels were very numerous and greatly distended, especially the veins, denoting passive congestion and added function of these vessels. There was absolutely no evidence of gangrene.

Possibly by this time the question has arisen, were we actually bringing about conditions that would lead to gangrene if the omentum were not so placed as to prevent the same. To satisfy our minds on this subject we did a simple control, cutting off the blood supply to 16 cm. of the lower ileum, using absolutely the same technique as in the preceding experiments, except in this case no omentum was placed about the gut. The following day the dog was plainly sick, the second day he showed signs of peritonitis, and on the third day died. Autopsy showed a general peritonitis. The intestine, where the blood supply had been cut off, evidenced marked gangrene; its lower part was ruptured, in fact almost completely everted for about 7 cm. The omentum, of its own accord, had made a noble effort to protect this area, being adherent for about 3 cm. along the upper border; here there was no perforation, the gut was lighter in color, and much healthier. The death of this, our control dog, from a peritonitis following gangrene and perforation of the gut after ligation of its blood supply proves, in our minds at least, that the omentum was the life-saving factor in the other four dogs.

SUMMARY

It seems to us that we have proved the omentum quite capable of caring for gastric and intestinal perforations of varying sizes; that it can be used to advantage in anastomotic work, and is capable of preventing gangrene of large areas of gut wall. Having seen the results of the experimental work, the last question that confronts us is, naturally, what are a few of the practical applications in abdominal surgery?

1. Since adhesions cannot be prevented, and since they do occur in a large majority of instances, make use of them.

2. Omental adhesions are less dangerous, therefore are preferable to adhesions between adjacent loops of gut.

3. Utilize the free border of the omentum at the time of operation rather than allow it and adjacent viscera to form promiscuous adhesions.

With this in view we advance a few surgical conditions in which it may be used:

1. In perforations caused by various means, gunshot wounds, perforated ulcers, as gastric, duodenal, typhoid, etc., where the patient is in a shocked condition, too weak or too asthenic for more extensive procedures, in other words where time is an important factor, this serous apron can be quickly sutured around the opening and the abdomen closed. In one of our clinics recently, where perforation was caused by an abscess from a gangrenous appendix, the patient not in a condition permitting resection, the omentum was wrapped around, and recovery followed, the operator proclaiming at the time, in his usual forcible manner: "Should obstructive adhesions form, two operations and a live patient are better than one operation and a mortuary."

2. To repair punctures in the mesentery.

3. For the protection of raw surfaces to prevent adhesions.

4. In excision of hepatic tumors the omentum may be utilized to advantage to give a broad base for the hæmostatic suture of the excision wound.

5. In drainage of the common bile-duct, wrap the omentum around the drain to prevent leakage. Also where a part of the common duct has been removed a new duct may be constructed of omentum.

6. For the relief of pyloric stenosis, cut through the stenosed area and lay the omentum over the wound.

7. Use the omentum to strengthen lines of abdominal vascular suture.

8. In all resection of bowel and anastomosis wrap the free border of the omentum around. Where resection must be done in the least possible time, the two ends of the gut may be approximated by a single through-and-through suture, and the omentum quickly placed around the wound with the saving of minutes.

9. We have shown that the omentum can be used to prevent gangrene; therefore in strangulation of the gut from numerous conditions, as for example, strangulated hernia, volvulus, etc., where there is doubt as to the viability of the gut, the omentum may have one of its greatest fields of usefulness. Likewise in mesenteric thrombosis where there is doubt as to the blood supply to a certain area.

The results of our work have been so uniformly positive and convincing that we feel no hesitancy in advancing our findings, with the hope that this work may be further enlarged, and eventually prove of practical operative value to the surgeon.

RECENT EXPERIMENTAL STUDIES OF THE PANCREAS

By HARRY H. PATRIE, LOUIS A. PYLE, and CLAIRE F. VALE

IN the past few years considerable experimental work has been undertaken with the primary idea of developing a practical method of re-establishing communication between the pancreas and the intestines, when the normal communication has been impeded or destroyed, or in such cases in which, for one reason or another, such as malignant disease of the head of the pancreas, or of the common duct, etc., it would be advisable to completely remove the head of the pancreas.

Before taking up the discussion of our problem in itself, it would perhaps be advisable to make a short résumé of the work already accomplished along this line. Coffey,[1] in 1909, first took up this work. His operation, which he called a pancreato-enterostomy, consisted of uniting a U-loop of the small intestine after the manner of the Finney pyloroplasty, and anastomosing into this loop the end of the pancreas. In the anastomosis he used the uncinate process, the tail and also the head of the pancreas, after removing the uncinate process by a partial pancreatectomy. His technique was of necessity quite complicated because of his idea that it was necessary to provide apposition of a considerable area of surface of the intestines with that of the pancreas, to prevent the possibility of leakage into the peritoneal cavity. The results of his work were satisfactory. Later he attempted, on a series of six dogs, an anastomosis of the pancreatic duct with the small intestines. His technique here was similar to that of a choledocho-enterostomy in which the duct is interposed between the coats of the intestines for an inch or so before being introduced into the lumen of the intestines, with the hope of producing a mechanical valve action by introducing the duct between the muscular coats of the gut. In this part of his work he was unable to get good results, and predicted that such an operation was unsafe if at all practicable. Within the past few years, the same idea of a pancreato-enterostomy was worked out in this laboratory, but with a much more simple technique. The procedure was simply to sew the cut end

[1] Ann. Surg., Phila., 1909, l, 1238.

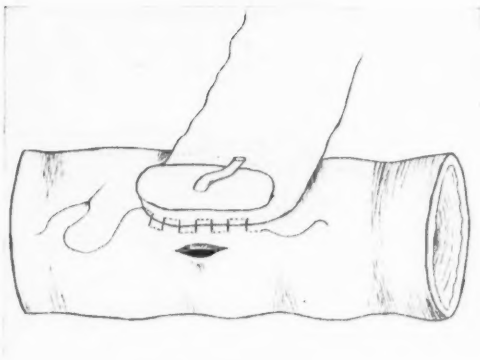

Fig. 1. Pancreato-enterostomy.

of the pancreas into a slit in the intestines, with a fine row of Lembert sutures, comparable to the first and last rows of sutures in a gastro-enterostomy. The operation was practically that of an end-to-side intestinal anastomosis, except that instead of simply being approximated to the wall, the end of the pancreas was tucked into the lumen of the gut. The result of this work was satisfactory and greatly simplified the elaborate technique of Coffey.

In any work on the pancreas, the all-important subject of acute pancreatitis, which has always made the surgeon so timid in pancreatic surgery, must be kept in mind. To review the work undertaken to determine the etiology of acute pancreatitis would be too long a task in the time allotted to us. Suffice it to say, that at present acute pancreatitis is considered a disease in which the proteolytic fermentogen of the gland, activated and set free, acts with its terrible digestive powers on the living tissues of the body. This activation may be produced by sterile autolysis, as from trauma of rough handling, etc., or by infection, which is thought to occur by way of the duct, the blood, and the lymphatics, and which, in causing a toxic death of the pancreatic cells, would compare with autolysis.

The human pancreas, in cross section, is too large in relation to the lumen of the gut to lend itself practically to such anastomosis as described above. Therefore, we undertook the problem of direct anastomosis of the ducts of the pancreas with the intestines, in an effort, first, to determine whether or not such a procedure would be successful; second, to determine which portions of the ducts could be used, if at all; and third, to make certain observations in regard to the etiology of acute pancreatitis.

In these operations, after occluding the existing ducts of the pancreas, we performed anastomosis of the duct of the uncinate process with the duodenum, of the main duct with the duodenum after removal of the uncinate process and the head, or of the duct of the tail with various loops of the small intestines and the colon.

The technique of our procedure was as follows: The main and accessory ducts of the pancreas were doubly ligated and cut between the ligatures. Then to prevent re-formation of the ducts, which occurs even after double ligation, a loop of omentum was carried between the cut ends and sutured in place. The uncinate process was freed and the end snipped off. By gauze dissection the ducts were stripped out for a distance of three-fourths of an inch. The posterior edge of the stump of pancreas was then sutured to the intestines by a continuous seroserous stitch, as is used in the first row of sutures of a gastro-enterostomy. A small puncture was made into the lumen of the gut and the free end of the duct pushed into it. Then the seroserous suture was completed around the anterior edge of the pancreatic stump (Fig. 1). In anastomosing the main duct the uncinate process was dissected from its attachments and it, and the head of the pancreas were removed. The main duct was then stripped out and anastomosed as before into the duodenum. In using the tail, we dissected it out for about three inches, and stripping out the duct as before, anastomosed it to any handy loop of jejunum, and to the transverse and descending colon.

The results of our experiments were as follows:

In a series of four dogs in which the duct was stripped from the uncinate process and anastomosed to the duodenum after the manner described above, all four dogs showed an uneventful and perfect clinical recovery. Autopsies after four, ten, eleven, and twelve

weeks respectively showed that the new ducts in all were patulous and of normal size. There was no evidence of leakage or suppuration, and only a few adhesions were present. The main and accessory ducts were closed in all four. The pancreas of one specimen was atrophied to a slight degree. The others were normal.

In a series of two dogs in which the uncinate process and the head were amputated and the duct of the proximal end was stripped up and implanted into the duodenum, both dogs also made a perfect recovery and showed no clinical symptoms. They were autopsied six and one-half and seven and one-half weeks after the operation and the implanted ducts were found open. There were a great many adhesions to the wound, but otherwise both were good specimens.

In our last series of ten dogs in which the duct was stripped from the tail and used for the anastomosis, the results were as follows: One dog died of distemper pneumonia seven days after the operation but the specimen even in that time showed a good result. Six dogs were sick for a day or two immediately following the operation but except for that made good recoveries, clinically. Four of these dogs, autopsied at five, five and one-half, seven, and eight weeks after operation, showed the old ducts closed and the implanted ducts open except for one in which no patulous ducts could be demonstrated. There was no fat necrosis, leakage, suppuration, pancreatitis or pancreatic atrophy, and scarcely any adhesions. In two dogs killed with gas seven weeks after operation, the main ducts were found patulous due to the fact that we had neglected to suture a loop of omentum between the cut ends. In one of these the implanted duct also functionated and in the other it was closed. No pathological findings were seen in or about the pancreas. The remaining three dogs of this last series developed acute pancreatitis and died, one, three, and five days respectively after operation. At the autopsy of the first, the peritoneal cavity contained a small quantity of bloody fluid, there were several patches of fat necrosis in the mesentery and omentum, and the tail and body of the pancreas were dark red. A small gauze sponge was found deep down against the pancreas which in itself was enough to account for the pancreatitis. The second dog on autopsy showed very beautiful fat necrosis. In the tail of the pancreas an abscess-cavity full of pus was found. The cause of this abscess was undoubtedly leakage from imperfect suturing. The third autopsy revealed bloody fluid in the peritoneal cavity and a mass of adhesions about the site of anastomosis, in the center of which an abscess was found as in the last case. There was some fat necrosis around the pancreas. Faulty technique was again the cause of this abscess.

CONCLUSIONS

1. The question of a direct anastomosis between the pancreatic ducts and the intestine is of comparative technical simplicity, and ought to be easily applicable to the human pancreas.

2. Any portion of the pancreatic duct can be used with equal ease. Our few failures when working with the duct of the tail we ascribe to the difficulty in getting at the tail, the pancreas having been subjected to more trauma and less perfect suturing.

3. Ascending infection of the duct did not occur in our experiments; it would seem, therefore, that the explanation of the ascending infection of glands with excretory ducts is not to be found in the assumption that the infection travels upward along the duct lumen or the duct mucosa. Even when we anastomosed the duct into the descending colon, where infection is most likely to occur, no pancreatitis developed.

4. The alleged sphincteric action of a band of circular muscle at the ampulla of Vater and the ampulla of the pancreatic duct, as a factor in preventing infection from the duodenum, can be discredited. In our anastomoses we created no such valve and yet we failed to get infection.

STUDIES ON THE TRANSPLANTATION OF THE URETERS INTO THE INTESTINES

By J. S. BAIRD, ROY L. SCOTT, AND R. D. SPENCER

DURING recent years, the problem of transplanting one or both ureters into the intestine has repeatedly been the subject of theoretical discussion and practical experiment. Some varying results have been obtained as to the possibility and expediency of this operation.

The first one to attempt this was Simon, who, in 1851, performed it for exstrophy of the bladder; and for the same condition Thomas Smith, in 1879, implanted both ureters into the colon extraperitoneally. In 1891, Kuester of Marburg, resected the whole bladder for carcinoma and implanted both ureters into the intestine. All three of these cases resulted fatally.

The first successful operation of this kind was performed by Chaput, in 1892. The case was one of ureterovaginal fistula and the ureter was united with the rectum by a double row of sutures. This patient survived for 13 years, and died of causes not pertaining to the operation. Many other cases may be cited since this work was started more than 25 years ago, and a great deal of experimental work has been done on the lower animals both in this country and abroad; but the results have lacked the uniformity that permits of a favorable prognosis in a high percentage of cases.

The indications for the performance of such an operation in man are rather rare. The principal ones are:

1. Injury of the ureter which cannot be sutured or implanted into the bladder.
2. Ureteral fistula.
3. Cystitis dolorosa (Trendelenburg).
4. Total cystectomy necessitated by malignancy or chronic infection.
5. Exstrophy of the bladder.

In attacking the problem of transplantation of the ureters into the intestines, it has been shown that general peritonitis, ascending infection of the kidneys, and cicatricial contraction of the opening into the intestine through which the ureter must pass are, in the order named, the three difficulties which oppose the success of the operation. Of these, ascending infection of the kidney is of the greatest importance, and this factor must be eliminated before there can be any hope of making this operation a success.

It is about this that we have concerned ourselves, but the first thing we must know is the pathology of its pathway to the kidney. Three routes for the ascent of infection to the kidney appear to be present: ureteral lumen, blood-vessels, and the periureteral lymphatics, if such there are.

The work done by Sweet and Stewart (1), in 1914, seems to prove conclusively that an extensive network of lymph-vessels and channels exists in the mucosa, submucosa, and external coats of the bladder and ureters, and in the entire kidney structure. This network in the ureter anastomoses freely with the lymphatics of the bladder at one end and the lymph apparatus of the kidney at the other. These investigators have apparently further established the fact that infection ascends through this lymph system alone and not through the blood-vessels or lumen of the ureter. The blood-vessels are excluded because the veins of the bladder and ureter for the greater part empty into the general venous circulation and not into the kidney venous system. The ureteral lumen can be excluded because, if the ureter be directly opened to infection, the infectious process can never be traced along the mucosa but it is found in the lymph-channels; and if the continuity of these lymph-channels be interrupted the infection does not ascend to the kidney at all. Furthermore, if the lumen be closed against infection, but the lymphatics be not disturbed, the infection ascends in the usual manner. Finally, it was demonstrated that if the kidney pelvis be directly connected with the intestine, the general infection characteristic of ascending infection does not occur.

If infection ascends along the lymphatics and not up the ureteral lumen we might succeed if we could avoid infection, i.e., not try to block infection by valve construction, etc., but escape the infection itself by preventing its occurrence. In any attempt to place the ureter into the bowel a wound of the bowel-wall must be made, and this becomes a lodging place for the pyogenic organisms always present in the intestinal contents. A pyogenic focus forms and we have the ureter ending in an abscess. If this focus be the source of the infection, could we avoid this ascending infection of the kidney by introducing the ureter not through a wound but through a normal opening in the bowel-wall?

We thought we could by utilizing the opening of one of the pancreatic ducts, since the dog, unlike man, has two such ducts, either one of which is capable of conducting the entire pancreatic secretion to the duodenum.

The technique of this procedure is as follows: A midline abdominal incision is made and the right ureter identified, isolated for the greater part of its course, and severed just above the bladder. A silk suture is then passed through the free end of the ureter. The main pancreatic duct having been identified, isolated, ligated, and cut between the ligature and intestine, the silk suture, threaded on a needle, is brought up and passed into the intestinal lumen through the pancreatic duct opening and carried through the intestinal wall directly opposite. The other end of the suture through the ureter is then passed through in a similar manner emerging from the gut about a centimeter from the other. Traction is then made upon these sutures and the end of the ureter is guided into the intestinal lumen through the duct opening. It is held in place by tying tightly the suture. Nothing further is done except to close the abdominal incision.

We present five cases in which this technique was carried out. At autopsy some seven to ten weeks later, there was absolutely no sign, grossly or microscopically, of an infection of the kidney. There were present the three possible tracts of infection to the kidney under practically the same conditions that formerly gave ascending infection.

Our work would seem to confirm the conclusions reached by others, who worked by different methods, that when the periureteral lymphatics are not directly in contact with a virulent infection there is no ascending infection of the kidney. By passing the ureter through a normal opening into the intestine we were able to eliminate this focus of virulent infection, which gains a foothold in the intestinal wound when an abnormal opening is made. Also that valve action at the ureteral opening is of inconsequential value.

Now, with one ureter transplanted into the intestine and ascending infection eliminated, the question arose as to whether or not this kidney would continue to functionate normally and, if so, would it be possible to transplant both ureters, thus pouring the entire urinary output into the intestine, with no bad results. We are aware that in birds and certain lower mammals, the cloaca, which acts as a common receptacle for both urine and fæces before ejection from the body, is the normal condition. Would it be possible to give rise to a similar condition in higher mammals?

To find the answers to these questions we proceeded as follows: Experiments were performed upon dogs with transplanted right ureters. The abdomen was opened and the left ureter identified, isolated, and a catheter inserted into it. Next the right ureter was cut near its entrance into the duodenum and a catheter inserted into it. During the next 45 minutes the right kidney excreted 15 cubic centimeters and the left 20 cubic centimeters, but the sodium chloride and total nitrogen content of the two specimens were equal. To test the renal function, one cubic centimeter of phenolsulphonephthalein was injected intravenously. The phthalein appeared 1 minute and 20 seconds earlier in the left kidney, but titration showed that the two specimens contained the same amount of phthalein during the subsequent period of collection. This leads to the conclusion that the right kidney was functionating properly and equally as well as the left.

To solve the second problem, we took dogs with transplanted right ureters, and after four to six weeks, did a left-sided nephrectomy. In all cases the right kidney appeared nor-

mal at this time. Within 48 hours came symptoms of nausea, vomiting, gradual loss of appetite, rapid emaciation. The dog would lie on his side and gradually become dull and stuporous, being hard to arouse, and finally dying in a comatose condition in from seven to twelve days.

Autopsy on these dogs showed no gross pathological lesions to account for their death. Furthermore, slight pressure along the pelvis of the kidney and the ureter was sufficient to express urine through the patulous opening of the ureter into the duodenum. These facts lead us to the conclusion that this one kidney was excreting normally and that the urine was gaining access to the duodenum.

It seems safe to conclude that the substances in the urine which, when retained give the symptoms of nephritis, can be absorbed from the intestine. Whatever this toxic substance in nephritis may be, it seems of considerable interest to note that it can be taken into the blood from the intestinal tract unchanged in its passage through the intestinal mucosa.

SUMMARY

1. Ascending infection travels up the ureter by the lymphatics and may be prevented by transplanting the ureter into an opening simulating a normal intestinal opening in such a way that it prevents the formation of a focus of infection at the immediate site.

2. That the kidney with its ureter so transplanted will continue to functionate normally.

3. That a valve action at the ureteral orifice is not essential.

4. That the entire urinary output cannot be drained into the upper intestinal tract, as its absorption gives toxic symptoms ending in death usually within twelve days.

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EXPERIMENTAL STUDIES IN COLONIC DILATATION

BY JOHN ALEXANDER, JOHN HANCOCK ARNETT, AND JAMES A. H. MAGOUN

EVEN before the publication of Metchnikoff's book *The Nature of Man*, in 1903 (1), there had been a growing tendency upon the part of some of the medical profession to regard the colon as to a great degree a vestigial structure, and to use the words of Dr. Barclay Smith of Cambridge (2), "a useless encumbrance to man."

Apparently Mansell Moullin was the first to perform the operation of anastomosis of the ileum into the colon, ileocolostomy, for chronic constipation (3). Sir William Arbuthnot Lane of London, in 1904 (4), published a monograph in which he described his success with the operation in glowing terms, and since then until 1909, was a most enthusiastic supporter of ileocolostomy as a means of curing cases of chronic intestinal stasis which proved intractable to other methods of treatment.

The fact that Lane several times modified his original operation, and in 1909 began to advocate excision of the colon instead of ileocolostomy (5), shows that up to that time the later operation could not have been a complete success; and the statistics reported from his clinic for excision of the colon show that even in the hands of this most skillful surgeon the mortality for this operation is high and the results are anything but brilliant (6).

What has led many surgeons to give up the operation of ileocolostomy for the cure of chronic constipation is a peculiar dilatation of the short circuited part of the colon which so often follows the operation. The fæcal material upon reaching the lower colon through the ileocolostomy opening backs up toward the cæcum, and distends this part of the colon until it becomes a huge sack full of fæces. Exactly how often this untoward result occurs following ileocolostomy is impossible to say, but from the literature upon the subject it would appear to be a compara-

tively frequent occurrence. Moynihan says: "In every case with one exception, in my own series there has been some regurgitation of the intestinal contents upward along the descending colon into the cæcum" (7).

In approaching the problem from the experimental standpoint we attempted to determine first, does dilation occur following ileocolostomy in the normal dog; second, what is the cause of the dilation? We made out the following list of the most plausible causes which have been put forward to explain this dilation; and proceeded to test whether they would produce the same condition in dogs.

Mechanical. Need for the stimulation given by the squirt through the normal ileocæcal valve (8).

Need for *vis-a-tergo* to push colonic contents onward. Obstruction produced by adhesions, kinks, etc. (9).

Rough materials stimulating bowels to peristalsis no longer pass into the cæcum, but through anastamosis instead.

Chemical. Toxic products and bacteria allowed to remain in contact with the wall of the colon.

Interference with blood supply to colon.

Autointoxication from colonic contents regurgitating into ileum (10).

Muscular. Area of increased tonus (11), at anastamosis leading to undue reverse peristalsis.

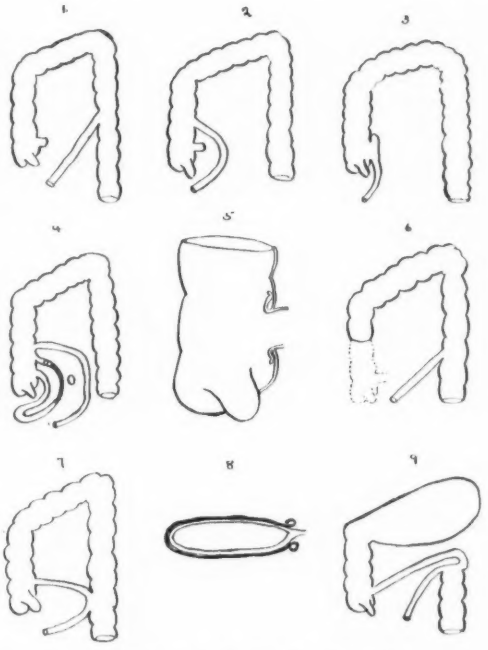
Muscle continuity of intestine broken.

Nervous. Nerves presiding over colonic movement injured. (a) Local neuromuscular mechanism (12). (b) Nerve-fibers.

Atony of the bowel resulting from any operation upon it.

We were unable to produce dilatation at all comparable to that which occurs in man, by any procedure resembling ileocolostomy as it is performed in the operating room. This answered the first question in our problem. Ileocolostomy in the normal dog does not produce noteworthy dilatation. It also demonstrated the following interesting facts:

1. That no factors on the list, single or in combination, could be proved capable of producing marked dilatation in a normal dog following ileocolostomy.



Diagrams of experimental operations.

1. End-to-side ileocolostomy upon six dogs. Ileum anastomosed at varying points into colon. No dilatation.
2. Ileum anastomosis close to valve in two dogs; one of these gave a slight dilatation which did not occur when the same operation was repeated.
3. Ileum proximal to valve severed. Ends turned in. Valve excised. Lateral anastomosis leaving a wide opening at the point previously occupied by the valve. One dog. No dilatation.
4. Lateral anastomosis without severance of the ileum. Lumen of ileum obliterated at *o* after thorough denudation of mucous membrane. One dog. No dilatation. Ileum found normally patulous at autopsy.
5. Mucous membrane of ileocæcal valve denuded and valve snipped leaving four flaps, which were stitched back. One dog. No dilatation.
6. Ileocæcal region excised, and anastomosis of ileum into colon below. Two dogs. No dilatation.
7. Lateral anastomosis without severance of ileum. One dog. No dilatation.
8. Same operation as No. 7, then a U-shaped copper wire as shown was sewed to the colon below the anastomosis so as partially to occlude its lumen and act as a foreign body irritant as well. One dog. No dilatation.
9. Distal end of sigmoid, end-to-side into ileum. One dog. Dilatation.

2. That the colon of the dog is, however, capable of huge dilatation (Experiment 9).

3. That animals in whom the contents of the colon are free to regurgitate into the

ileum do not suffer from autointoxication as suggested by Kellogg (10). Such dogs weighed by us averaged an increase of body weight of 748 grams in 157 days.

4. That if there is any myoneural mechanism at the ileocæcal region as suggested by Keith (12), this is not essential to the emptying of the colon itself. (Experiment 6).

5. That even in the presence of a wide ileocolostomy opening, unless the ileum is excised proximal to the valve the fæcal current has a strong tendency to follow its normal course (Experiments 4 and 9).

The routine which we pursued in our work was as follows: The dogs were weighed before operation and before autopsy. To record the size of the colon above and below the ileocæcal valve nine measurements were made at fixed distances above and below the valve, the gut being measured in two perpendicular diameters. The time between operations and autopsy varied between 20 and 195 days. Results from dogs dying in less than 20 days were discarded.

In searching for the explanation of dilatation after ileocolostomy perhaps surgeons have been too prone to look to the operation itself or some fault in technique as the cause of the dilatation. We tried various operative techniques and deliberately produced the results of errors in technique and yet we failed to get any marked dilatation. We were forced, therefore, to give up the idea that dilatation of the colon following ileocolostomy is due chiefly to the operation itself or faulty technique in its execution, and to accept the view suggested by Ochsner (9) and others, that the underlying cause for the stasis for which the operation was performed was also the cause of the dilatation itself.

What the explanation for the original stasis may be, whether due to a neurosis, to infection, to faults in the sympathetic nervous system or ductless gland system, to diminution in the tone of all the muscles of the body (14), or a preceding trauma to the colon from too great distention (Experiment 9), or other causes must be the subject of further investigation. However, until the causes of chronic intestinal stasis are better understood the operation of simple ileocolostomy should be abandoned, for in a large number of cases the same cause which produced the indication for the operation will also cause its failure. Furthermore, we have no means of determining, as yet, just how far a colon may be damaged by chronic intestinal stasis and recover. There is obviously no use in operating upon a colon to rest it by a short circuiting operation when the entire wall has already been damaged beyond recovery. This is one more reason for giving up simple ileocolostomy. The operation should be abandoned until the cause of the intestinal stasis and the pathology which it produces are thoroughly understood.

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DEPARTMENT OF TECHNIQUE

A TECHNIQUE FOR DRAINAGE OR EXCISION OF THE SEMINAL VESICLE

By JOHN H. CUNNINGHAM, Jr., M.D., F.A.C.S., Boston

IN the year 1901, Dr. Eugene Fuller presented a technique for drainage of the seminal vesicles, enumerated a type of case in which he considered it applicable, and recorded the result in a small series of patients upon whom he performed the operation. Since that time he has written much upon the subject, pointing out the symptomatology, indicating the procedure, and has given the results in a series of over 300 cases.

For whatever reason, the genito-urinary surgeon has been slow to appreciate what Dr. Fuller has repeatedly shown, but at present the truth of his teaching is fully appreciated by those who have learned to recognize the types of cases suitable for seminal vesiculotomy. Due credit will unquestionably be given to Fuller as the value of the practice of surgical drainage of infected seminal vesicles is more generally realized; and the profession will remain indebted to him for it, as it has for instituting the practice of massage of the vesicles and prostate in certain diseased conditions of these structures.

In selecting cases for seminal vesiculotomy we include those who have had any of the local or general manifestations dependent upon focal infections in these organs which cannot be overcome by the usual non-operating methods of treatment.

The pathological classification consists solely of acute to chronic, non-tubercular, grades of inflammation of the genital tract, beginning with the prostatic urethra and including the structures therein — the prostate, vesicle, vas, or epididymis — with the predominating features of the inflammation located in the seminal vesicles. It is the retention of the products of inflammation in the seminal vesicles and in some degree in the prostate that results in the clinical symptoms, both local and general.

A clinical classification which serves to select the cases suitable for operation is based on the most important symptom or group of symptoms, but it must be obvious that such a classification must be most arbitrary, as different groups of symptoms often exist together in some measure in many cases. The following classification is based on the most prominent subjective symptoms and the objective findings:

1. *Inflammatory group.* a. Acute suppuration, occurring most often in the vesicles and prostate in the course of acute urethritis, resulting in a febrile state and presenting locally, a swollen, tender prostate and distended painful vesicles. The condition is generally treated by confinement in bed, local applications and drugs to relieve pain, with the result that after the acute process subsides there persists a urethral discharge from subacute or chronic seminal vesiculitis and prostatits which lasts for weeks or months even with appropriate local treatment.

b. The chronic inflammation which has but a slight or no severe acute stage, characterized by an obstinate urethral discharge, proved not to originate from the anterior urethra, and the material expressed from the vesicles and prostate showing, by massage or coitus, fresh or old blood or the products of inflammation in the gross and microscopical examinations. Cases of recurrent epididymitis associated with the condition just mentioned, and ejaculation of bloody semen, point to disease in the vesicles. While most of the cases of this group may be cured by appropriate non-operative treatment, there are others which cannot be sufficiently drained through the natural channels and which must be subjected to operative drainage of the vesicles and prostate to effect a cure. There are cases of cystitis which can be explained in no other way than by the extension of the inflammation in the vesicles to the bladder wall and mucosa.

2. *Pain group.* Under this heading is included those with persistent perineal pain, sometimes accentuated by defæcation and often referred to the rectum; indefinite in character, but extremely disturbing to the individual and often associated with neurothenic symptoms, painful erections without sexual stimulus, frequent nocturnal emissions, sometimes painful, and bloody semen.

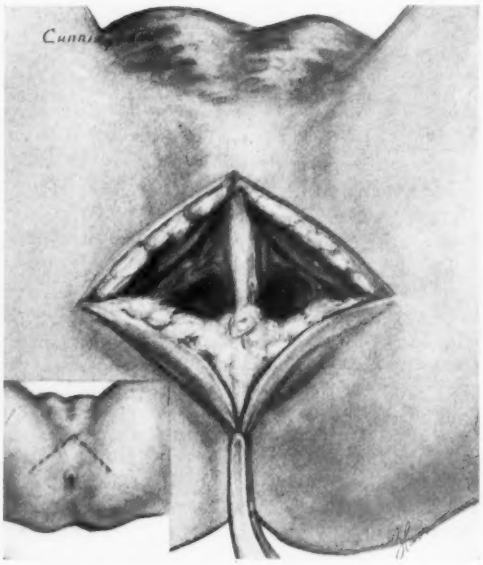

Fig. 1. Shows skin flap dissected and retracted downward, exposing bulb of the urethra and the median perineal tendon. On either side of the median tendon, the openings into the ischiorectal fossa are seen. Insert shows outline of skin incision.

Fig. 2. Shows the index and second fingers of the left hand inserted into the fossæ holding the rectum downward, while the median tendon and recto-urethralis muscle are divided. Dotted line on perineal tendon shows line of incision.

This group usually gives a history of a previous urethritis, and in the absence of rectal or bladder disease, and the presence of palpable changes in the prostate and vesicles associated with abnormal elements in the fluid expressed from those organs, the cause of pain may be attributed to disease in these structures. Changes in the verumontanum may be associated with the changes in the prostate and vesicles and occasionally treatment of this structure alone may relieve the distressing symptoms.

3. *Neurasthenic group.* Under this heading is included those with the physical findings of disease in the vesicles already enumerated and mental symptoms in the nature of depression, melancholia and apprehension, associated especially with sexual features; the so-called sexual neurasthenia.

4. *Rheumatism group.* Under this heading is included joint, tendon, muscle, and bone lesions which may be dependent upon a focal infection. Gonorrhœal seminal vesiculitis and prostatitis with metastatic lesions fall into the same class of focal infection as those arising from teeth abscesses, tonsillar infections or other poorly drained infective foci, from which other parts of the body become secondarily invaded by emboli or toxines entering the blood stream. In searching for the focus which will explain a so-called rheumatic manifestation, much differentiated study may be necessary in some cases; but in the differential diagnoses, the condition of the prostate and seminal vesicles should be included.

OPERATION

The technique here detailed is the result of not being satisfied with the procedure of incising the vesicles by the sense of touch as practiced by Fuller and the demonstration, by Squire, that the vesicles can be exposed to view. Many directions on the cadaver has developed the following technique which has been employed in 116 cases without mortality.

Technique. Patient in exaggerated perineal position. An inverted V-shaped skin incision follows the bony arch of the pelvis, the apex in front and the lateral incisions extending backward to the tuberosities of the ischium. The skin flap, so outlined and including fat, is dissected from the underlying structures exposing the bulb of the urethra and the perineal tendon. The fossa on either side of the median tendon in front of the transversus perinei muscle, is opened as deep as possible by blunt dissection with the index finger,

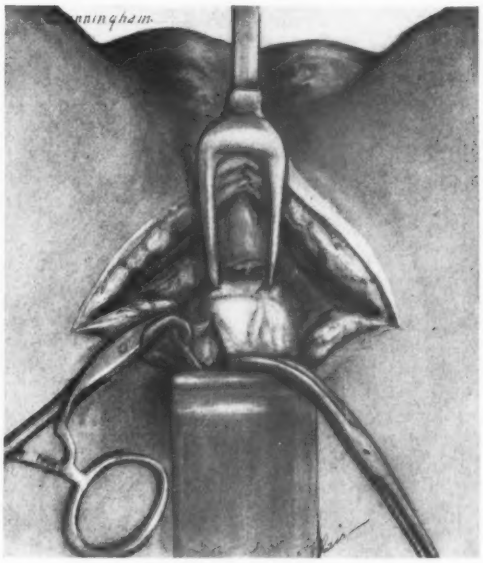

Fig. 3. Shows special double tenaculum inserted into the prostate just in front of the junction of the prostate with the bladder, elevating the prostate and exposing the vesicle area. One vesicle is seen showing through the fascia of Desnonvillier; and on the other side the fascia divided and retracted, exposing the vesicle. At the bottom of wound special retractor over rectum.

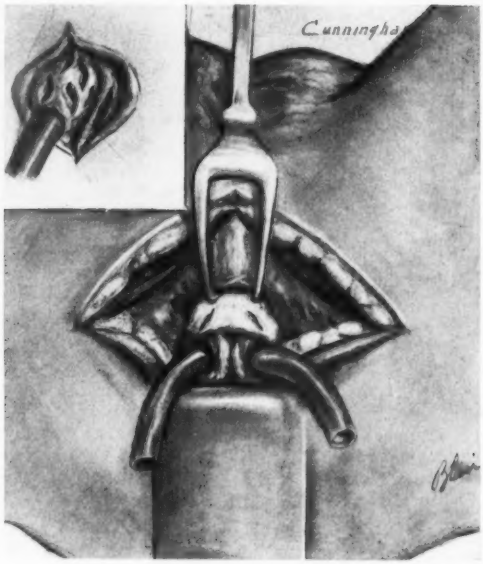

Fig. 4. Shows the drainage tubes caught in the structure of the vesicles by a catgut suture and the incisions into the prostate tissue. Both vasa deferentia are seen between the tubes. Insert shows in detail the opened ducts of the vesicle with sutured tube in position, the opened vas deferens and the retracted fascia of Desnonvillier.

identifying the apex and the posterior surface of the prostate and freeing the rectum from it as much as possible (Fig. 1). The index and second finger of the left hand are then placed in the fossæ pressing the rectum downward, and the median tendon and recto-urethralis muscle which attached the rectum to the urethra is divided as near the bulb of the urethra as possible (Fig. 2). With division of the recto-urethral attachment the muscular fibers of the levator ani muscles may be seen attached to the posterior surface of the prostate and these fibers are freed by blunt dissection, from the posterior, and partially from the lateral, surfaces of the prostate. This blunt dissection, freeing the rectum, is carried beyond the junction of the prostate with the bladder, exposing the vesicle area and the base of the bladder.

The rectum is protected by a piece of gauze placed to the bottom of the wound; and a flat retractor either 1½ or 2 inches in width, according to the width of the bony pelvis, and with an abrupt curve and long enough to reach the bottom of the wound, is inserted. This special retractor is furnished with a weight so that it is self-retaining. The posterior surface of the prostate and bladder are now visible. A special double tenaculum is inserted into the prostate tissue just below its junction with the bladder. By lifting the prostate with this instrument, the base of the bladder and the vesicles may be visible beneath the fascia of Desnonvillier, provided this fascia is not much thickened by inflammatory exudate. The sulcus in the median line, between the vesicles, may often be palpated, which, however, is not necessary if the dissection is carried well above the superior border of the prostate. The fascia in the vesicle area, on first one side and then the other, is picked up and divided and should be so freed as to bring the vas deferens into view and to allow the vesicles to be picked up with forceps and drawn out through the fascial incision (Fig. 3). The fascia varies greatly in thickness, being normally as thick as writing paper, may be nearly one-quarter of an inch thick when involved in extensive perivesiculitis. While there is usually a line of cleavage between the fascia and the vesicles, the fascia and vesicles may occasionally be so bound together that they cannot be freed from one

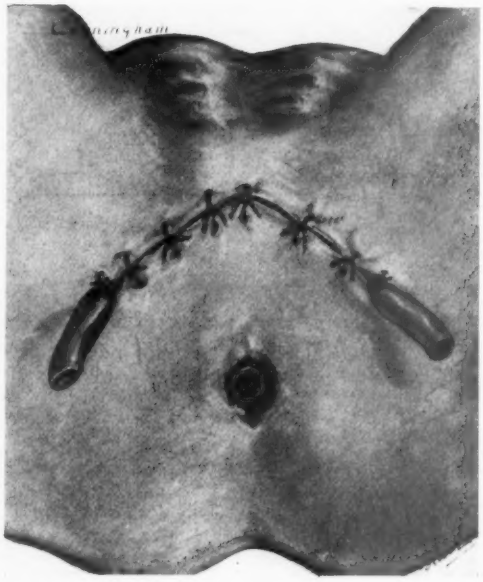

Fig. 5. Shows the wound closed by interrupted silkworm-gut sutures, with drainage tubes at either angle of the wound. Also the rectal plug made of rubber tubing and gauze.

another, and the vesicle must be opened without freeing the fascia from it. The vesicle being exposed, it is not opened by multiple incisions, but by cutting away the posterior wall and thus giving it freer drainage. If the ampulla of the vas is dilated, it also should be incised. With the vesicle well opened, its interior is swabbed with crude carbolic acid. If preferred, the vesicle may be dissected unopened from its bed and removed in suitable cases. Small rubber tubes are caught in its structure by a No. 1 plain catgut suture. The prostate tenaculum is removed and the prostatic capsule freely incised over each lateral lobe and several incisions made into the prostate tissue, a part or the whole prostate may be removed, as it is believed that infection lurks therein to some degree in nearly, if not all, instances of seminal vesicle infection (Fig. 4). The retractor and gauze protecting the rectum is removed and the rectum inspected to be sure that it has not been opened. If the rectum has been opened it should be repaired by a catgut suture. The divided perineal muscles are united by a running catgut suture, taking pains to pick up the fibers of the levator ani muscles.

After the divided muscles and the median tendon have been united, the skin-flap is replaced and the external wound closed by interrupted silkworm-gut sutures, and the drainage tubes, sutured into the vesicles, protruding from either angle of the wound. A rectal plug consisting of a rubber tube four inches long and surrounded by iodoform gauze, is inserted into the rectum and held by suture to the anal margin. In this way the rectum is made to occupy more nearly its normal position and close the space above the muscular repair. By thus filling the dissected space, oozing is less apt to result in an accumulation, and the rectum being held open by the tube allows the escape of gas during the period that the bowels are confined.

An adhesive plaster scrotal dressing which holds the testicles well elevated is applied to prevent the possibility of epididymitis, which is prone to occur. A dry dressing is applied and held in position by a "T" bandage.

The after-care consists in keeping the patient on a light diet, the administration of pill opii, grains one, morning and night for five days; to prevent movement of the bowels. On the sixth day the pill opii is omitted, the rectal plug removed and an oil enema of two ounces is injected into the rectum through a long-nosed syringe, and a dose of castor oil administered. The patient is then placed on a more substantial diet. Two corrosive dressings are applied to the wound daily, and the drainage tubes are allowed to remain from ten to fourteen days. Earlier removal of these tubes may prevent sufficient drainage and result in the recurrence of symptoms. The areas occupied by the tubes usually heal in from three to five days following their removal. A suspensory bandage should be worn for a period of at least one month.

Many of the cases in the "rheumatic group" have been treated by gonococcus and streptococcus vaccine; but those not so treated have remained cured. Cases in the "pus group" have, with few exceptions, required no further treatment of the prostate and vesicles by massage or deep installations.

THE TREATMENT OF COMPOUND FRACTURES OF THE HUMERUS AND FEMUR BY NEW APPARATUS

By H. T. BUCKNER, M.D., Seattle, Washington

SINCE the beginning of the present great European war, many new apparatus have been devised for the treatment of compound fractures, some of which have proved very successful and all of which have their good qualities in certain cases.

In this paper I wish to present two new apparatus that have proved very successful in many respects. The apparatus for the treatment of fractures of the humerus was devised by Doctor Lisandro Leyva of Bogota, Colombia, and the one for fractures of the femur was devised by myself. Both were constructed and are being used at the American Ambulance Hospital of Paris.

In the treatment of bones fractured by modern war implements, many things must be taken into consideration, especially the size of the wound, the amount of comminution of the fracture, the amount of substance lost, the amount and kind of infection and what kind of result can be obtained.

Both of the apparatus have many points in common, points that are very essential in the treatment of fractures.

1. They are open or can be adjusted so that a wound in almost any position can be easily reached, and thus any method desired may be used for the sterilization of the wound.

2. They are adjustable so that the arm or leg can be put in any plane, in order to obtain the proper alignment.

3. They have many adjustable parts so that all the joints can be moved, thus preventing ankylosis.

4. Extension can be applied and maintained continuously.

5. They are adjustable so that they can be used on either the right or left side.

6. The bone can be firmly fixed, yet there is free access to examine the skin so that any undue pressure in any one part may be detected and overcome.

7. With the arm apparatus the patient can be up and around without any interruption to his progress. He does not have any difficulty in lying down. He can lie either on his sound side or on his back. He can be taken to the fluoroscopic room and examined with the apparatus applied, to see that the proper reduction has been made.

With the femur splint, as with all others, the patient must remain in bed, yet X-ray pictures can be taken with the splint applied.

I shall consider each apparatus separately, giving a description of each, with some case histories and X-ray pictures of the results obtained.

ARM APPARATUS

The arm apparatus really consists of two parts. A body piece and a metal frame to support the arm.

Figure 1 is a photograph of the apparatus without the body plate. To the bars *A-B* and *C-D* is attached a piece of aluminum 25x50 centimeters which is curved so as to fit around the body. The lower edge is turned outward so the sharp edge will not produce pressure on the crest of the ileum. The aluminum plate is well padded with cotton and covered with canvas. Three

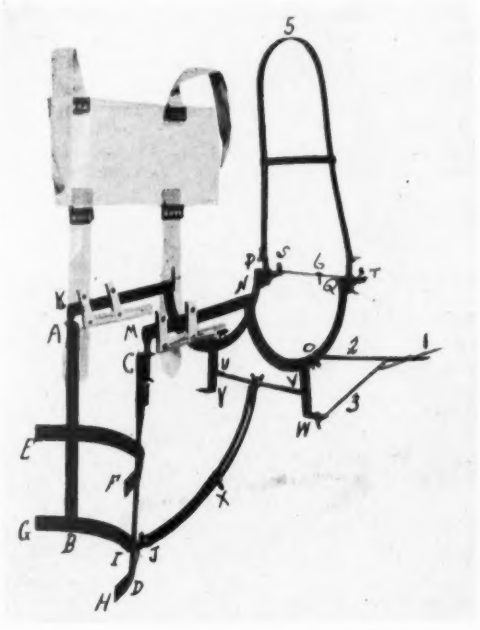

Fig. 1. Arm apparatus without the body plate. Full description is given in text.

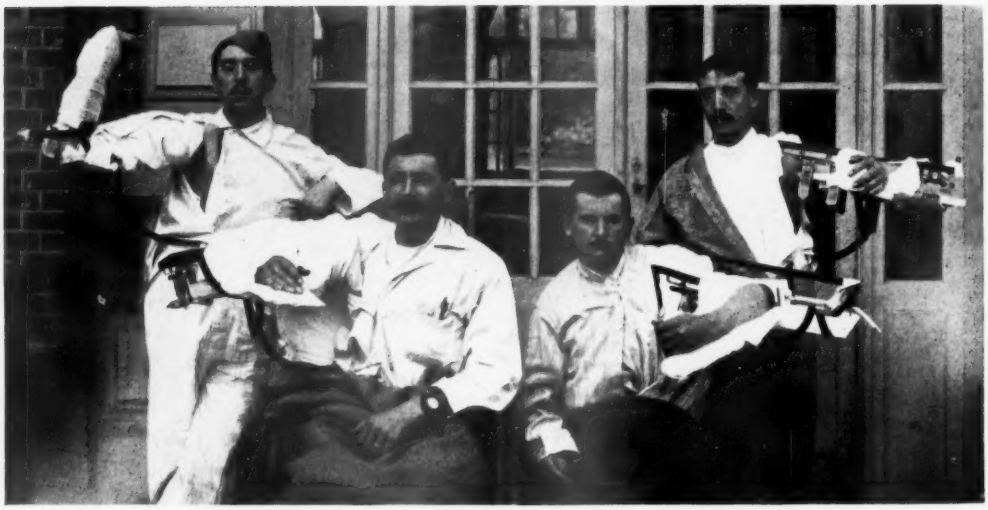

Fig. 2. Shows the arm apparatus applied. The forearm can be put in supination, pronation, midsupination and pronation, or in the erect position.

buckles are applied to each end. The two middle ones being turned somewhat upward.

Two canvas straps pass around the body and another over the shoulder on the sound side. These straps attach to the mentioned buckles. These straps must also be padded, especially the one that passes over the shoulder. The arm then rests in a little hammock that is attached to some pulleys that run on the bars *K-L* and *M-N*.

The forearm can be put in supination, pronation, midsupination and pronation or in the erect position as presented in the picture (Fig. 2). When the forearm is placed horizontally, the forearm part marked *1*, *2*, and *3* (Fig. 1) is used. This can be placed on either side according to which humerus is fractured. When the arm is placed vertically, then the arch part *5* is used. This can be placed anywhere along the frame, depending upon the length of the humerus.

It is advantageous to pad a thin splint and place it in the hammock for the arm to rest on, as it makes the base a little more firm. Another short splint should be padded for the forearm and attached to bar *2*.

One of the very essential things in the treatment of fractures is extension. This can be applied very easily with either apparatus. It can be made by applying adhesive strips or gluing short canton flannel strips to the humerus. To the ends of these strips is attached a small piece of wood. To this piece of wood is attached a piece of square rubber that is pulled as tight as is necessary and fastened at the point *6* in the bar *S-T*. If you desire to know just how much pull there is on the humerus, you can attach a known amount of weight to the end of the rubber, and while the weights are pulling, attach the rubber at the mentioned point, after which the weights can be removed. Usually it takes from three to four kilos for a humerus.

Sometimes the wounds are so large that there is not sufficient space to attach the extension straps directly to the humerus. Then a figure-of-eight bandage is put around the elbow, and the rubber attached to the ends of it.

In dressing the wounds, they can be easily reached if they are on the outer, anterior, or posterior aspect of the arm. If they are on the under surface of the arm, the buckles on one or both sides are loosened and the splints are removed, when the under surface will be exposed.

One of the real features of both these apparatus is the moving of all the joints without interfering with the progress of the union of the fracture. By simply opening the bolt at the point *X*, the frames can be lowered or raised thus moving the arm with it. Opening the bolt at *J* the arm can be moved forward and backward, making another very essential movement. When the forearm is placed horizontally opening the bolts at *O* and *W*, the forearm can be considerably flexed and extended. When the forearm is

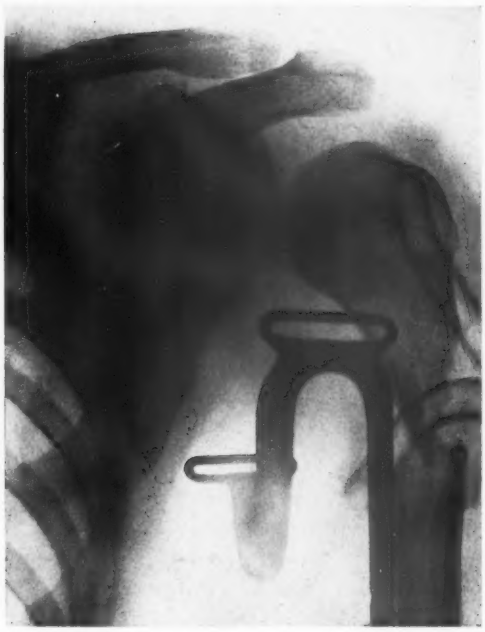

Fig. 3 Case 2, wounded March 4, 1916. Roentgenogram taken April 22 with the Delbet apparatus applied.

placed vertically, the bolts at *S* and *T* can be opened to produce the same movement. By simply grasping the wrist and raising the forearm just a little, the forearm can be supinated or pronated enough to keep the joint fluid stimulated.

If the extension is well placed and is fairly firm, all these mentioned movements can be made without moving either fragment, and with very little, if any pain to the patient.

TREATMENT OF THE WOUNDS

The wounds are treated with intermittent irrigations through small perforated rubber tubes as described by Dr. Alexis Carrel of the Rockefeller Institute. The rubber tubes are of very small caliber with one end closed.

The depth of the wound is estimated and many holes are punched in the tubes extending from the ligature or tied end to the skin surface. Many holes are punched so that when the fluid is run in, the tube will act as a spray and all parts of the wound will be reached by the fluid. The holes must be small and they are best made by heating a needle and passing it through the tube.

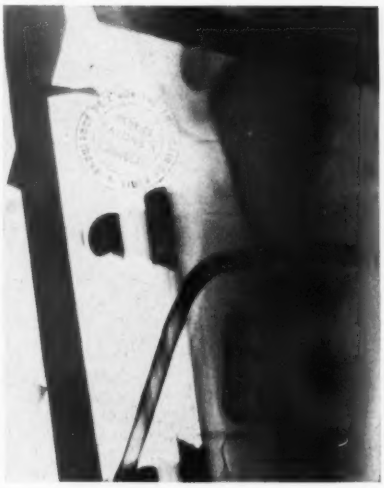

Fig. 4. Roentgenogram taken of Case 2 after reduction of fracture and application of Leyva apparatus.

As many tubes are used as there are places or pockets for the pus to collect.

The tubes that run across the surface area of the wound seem to distribute the fluid a little better if a piece of Turkish toweling is wrapped around the tube. The Turkish toweling only extends from the ligated end to above the perforations. The uncovered tubes seem to work

Fig. 5. Roentgenogram of Case 2, June 1, showing firm union. Apparatus removed.

Fig. 6. Case 3, wounded April 6, 1916. Roentgenogram taken April 10, without apparatus.

better down in the wounds. The tubes are held in place by a little plain gauze and this is placed in very loosely so as not to interfere with the return flow of the liquid or the drainage.

We use a large cotton pad for the dressing and we make a hole in the center of it and pull the ends of the tubes through. These tubes are then connected up with glass connecting tubes which have from two to four outlets.

The solution used for the irrigations is the one described by Doctor Dakin of the Rockefeller Institute, and it consists of

	Grams to the Liter of Sterile Water
Chloride of lime	20
Sodium carbonate dry	10
Sodium bicarbonate	8

The chloride of lime is put in a flask with a half liter of sterile water and shaken thoroughly and then allowed to stand over night. The sodium carbonate (dry) and bicarbonate are then put in another half liter of sterile water and dissolved. The two mixtures are put together and shaken thoroughly again and allowed to stand for a time and then the clear solution siphoned off and filtered. Cold water should always be used and the solution should be used at room temperature as heat will decompose it, liberating chlorine,

Fig. 7. Roentgenogram of Case 3 taken April 19, showing the Leclair apparatus applied.

Fig. 8. Roentgenogram of Case 3 taken after the Leyva apparatus had been applied.

thus rendering the solution inactive. The solution is used in a 1:200 dilution.

The irrigations are best made from an irrigation bottle that is placed at a fixed height so the same pressure will be exerted each time. The bottle is placed one meter above the wound. A rubber tube runs from the bottle to the glass connecting tips. This tube should be of sufficient caliber so that when the solution is turned on it will fill the glass tips entirely, thus permitting the solution to run out in equal quantities from the small outlets.

Sometimes a glass dropping chamber is inserted in this tubing from the bottle for a continuous drip, but this does not seem to work so well, as the small glass connecting tip will not be filled entirely and the solution will go out only one or two of the outlets, thus sterilizing only part of the wound.

It is always best to keep the tubes connected with the bottle and the tubes filled with the solution, so that if any bacteria lodge in the tubes they will be killed and live bacteria will not be rejected into the wound. The irrigations are made every two hours night and day. If the tubes are connected with the irrigating bottle, the irrigations can be made at night without any interruption to the patient's sleep. The solution is often quite irritating to some skin, and inflammation is largely prevented by putting vaselined gauze around the wound. This is prepared by pouring melted vaseline over sterile gauze and allowing it to harden. A large piece of gauze is often better than several small pieces, as the one large piece can be opened up and spread out over the wound and skin, and the part that is just over the wound cut away. By smoothing out the gauze, the skin can usually be fairly well protected. As a rule the vaseline gauze does not have to be changed every day, but if the suppuration is marked and it is soiled, then it is better to change it.

The changing of the dressings depends upon the amount of suppuration; as a rule once in twenty-four hours is sufficient but if the suppuration is marked and a large amount of solution must be used, then it will be necessary to change the dressing a little more frequently.

The quantity of the solution necessary depends upon the size of the wound and in most cases just a few hundred cubic centimeters is sufficient. The wounds are not irrigated to the extent of being flushed, but are simply filled with the solution. When a tube comes out it is always a good rule to put in another that is absolutely sterile rather than try to cleanse the one that came out.

Smears are made from the wound every day or so and the number of bacteria noted per field. If the bacteria do not seem to decrease, then the strength of the solution should be increased or it should be used a little more frequently. When several slides on successive days are found sterile, or free from bacteria, then the wound may be closed. This is done either by a few silkworm sutures, or better still, by putting some hooks on adhesive plaster, sterilizing, placing on each side of the wound, and then lacing the wound closed by means of rubber bands.

This method does not close the wound so tight, but that if a secondary abscess develops, the pus will find its way out much easier. The technique described has proved very efficient in cases of most violent infection.

CASE 1. L. M., aged 32, wounded by a piece of shell, on April 2, 1916, in the battle of Verdun. The patient was transferred in plaster and arrived at the American Ambulance Hospital on April 8. He was found to have a very large suppurating wound, six centimeters long, extending through the arm. On April 8, a roentgenogram was taken without the apparatus applied. The wound was dressed as described above and the apparatus applied. On May 22 the wound was entirely closed and firm union of the fracture had taken place.

This patient not only had firm union of his fracture but did not have ankylosis of any joint.

CASE 2. H. P., aged 28, wounded by a fragment of shell March 4, 1916, in the battle of La Cheppe. This patient was transported with the Delbet apparatus, and arrived at the American Ambulance Hospital March 31, 1916.

He was found to have a large wound of the right arm, extending two-thirds the length of the arm with marked suppuration and no unions. He had some ankylosis of the elbow-joint. The same apparatus was left on till April 22 when the suppuration continued and union had not taken place. Figure 3 was taken at this time. On account of the findings in this picture, the Delbet apparatus was removed and the Leyva apparatus applied. The wound was then dressed as above. The patient was taken to the fluoroscopic room and the fracture reduced. Figure 4 was taken.

On May 20 the wound was entirely healed. On June 1 firm union had taken place and the apparatus was removed with the result shown in Fig. 5.

Firm union was also obtained in this case and the partial ankylosis in his elbows was broken up at the time the apparatus was removed.

CASE 3. L. M., aged 20, wounded in the right thigh by a fragment of shell, on April 6, 1916, in the battle of Verdun. When he fell he fractured his left humerus, but the fracture was only a simple one. He was transported in plaster and arrived at the American Ambulance Hospital of Paris on April 10, at which time Figure 6 was taken without the apparatus.

The Leclair apparatus was applied and on April 19, 1916, Figure 7 was taken.

In view of the above result the Leyva apparatus was applied and on June 1 the patient had firm union, as shown in Figure 8.

All the above cases were studied with the X-ray and fluoroscope. Of the following case I had

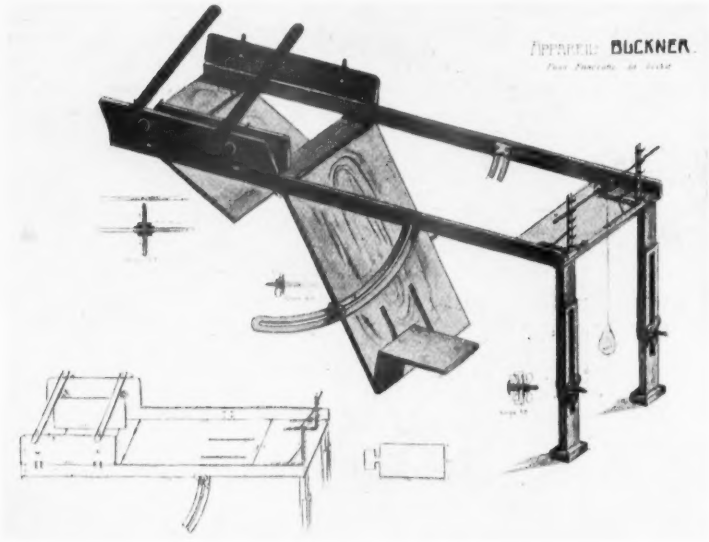

Fig. 9. Femur apparatus. Full description is given in the text.

no pictures taken until union had taken place and the apparatus had been removed.

CASE 4. This patient was wounded in the battle of Verdun on March 30 and arrived at the American Ambulance on April 7. He had been wounded by a fragment of shell and transported in plaster. He had a very large wound of his right arm with marked infection. The above method was used in the sterilization of the wound. The wound healed in three weeks. The apparatus was left on six weeks, after which sufficient union had taken place, so that the apparatus could be removed.

All these cases and many others recovered without any secondary complications, as well as being fairly comfortable with the apparatus.

FEMUR APPARATUS

I shall make only a preliminary report of the femur apparatus. It is made almost entirely of wood and simulates a fracture box in many respects, but is much more practical, as it can be adjusted to almost any plane (Fig. 9).

The apparatus is well explained in the above photograph. The splint is put on the bed and the leg placed in it. It can be applied to either the left or right side. The splint can be placed straight on the bed extending over the foot, in which case the ordinary hospital bed or some bed with a low foot board must be used, or the splint may be placed off to the side of the bed. It can be placed at any angle, depending upon the amount of abduction that is necessary.

Figures 10 and 11 represent the apparatus placed off one side of the bed. (In this instance the patient had a high fracture and the proper reduction was obtained at this angle.) The leg is put in the splint and the femur is held in place by coaptation splints. The sides of the splints are on hinges and can be opened or closed. They are held closed by two cross bars of wood. The leg is placed in the splint to the inner side. There is an adjustable coaptation splint which is the length of the femur, and this can be screwed up against the femur, thus splinting it firmly. The sides of the splint must be closed before the coaptation splint can be tightened.

The leg can be extended as shown in Figure 11 or it can be flexed as in Figure 10 at any angle. The leg is placed on a little chariot, which is simply a piece of aluminum with a wire frame on the end of it for the foot to rest against. The end of the frame is cut circular, so as to prevent any pressure on the heel. Two small pulley wheels are put on each side and they run on a heavy wire track. This little chariot arrangement is simply to release the friction and render the pull more upon the femur.

Two sets of extension straps are used; one long and one short. The long ones are fastened to the femur and as high up as possible. They are attached to some buckles that are fastened to a small block of wood to which the extension

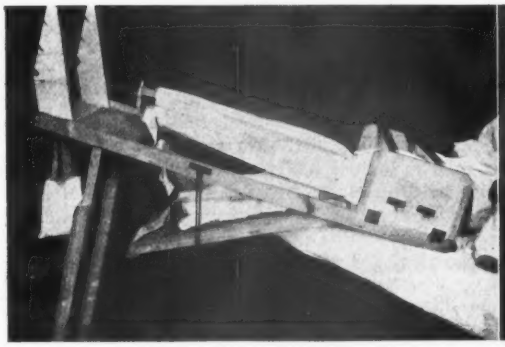

Fig. 10. Application of the femur apparatus, showing the possibility of flexing the leg at any angle.

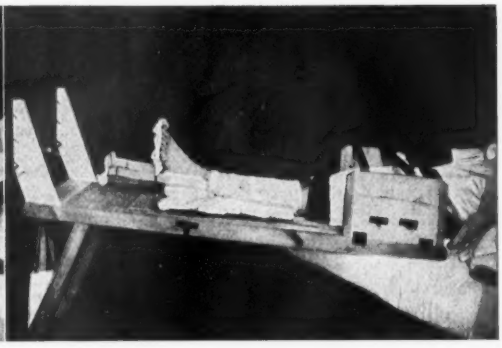

Fig. 11. Application of the femur apparatus, with leg extended and all straps tightened.

cord is fastened. The short ones are attached to the leg below the knee and they attach also to two other buckles fastened to the same block.

The reason for the two sets of extension straps is that when you wish to flex the knee, the straps can be loosened and the knee flexed without interfering with the extension upon the femur. Figure 10 represents the straps loosened and the knee flexed; Figure 11 shows all the straps fixed and the leg is placed straight.

If the extension straps are placed fairly firm and the coaptation splint is tight, every joint can be moved without moving either fragment or producing much pain.

The patient can sit up straight in bed, moving the hip-joint. The hip-joint can also be moved by opening the bolts on the legs and raising the frame. When the frame is raised, the weights are also raised, thus keeping up the pull.

The knee can be flexed by simply loosening the straps and dropping the bottom.

The ankle-joint can be manipulated with the hand.

It is customary to move each joint a little each morning and leave it in a different position for a short time as this seems to prevent the formation of ankylosis.

The dressing of the cases is perfectly simple with this apparatus, as the sides open out and the femur is easily reached. The under surface of the femur can be reached by opening the bolts on the legs, raising the frame fairly high and then opening the part or door under the femur.

The apparatus has many distinct advantages.

1. If the legs are attached to the floor the apparatus is firm and the femur can be firmly fixed in it.

2. The leg can be placed at any angle of abduction, adduction, or elevation.

3. Each joint can be moved; extension and dressings can be easily applied.

It might seem that the inner side of the splint would hurt the patient, but this difficulty is overcome by applying a cotton pad over the end of the board.

In a later paper, I shall present a series of cases with the X-ray results obtained with this apparatus.

IMMEDIATE COMPLETE AMPUTATION OF THE UMBILICAL CORD[1]

By ROBERT L. DICKINSON, M.D., F.A.C.S., Brooklyn

AGAIN, after nearly twenty years, I bring forward the petition that the only piece of surgery which has to be done on every human being should have its standard set not by midwife timidity, but by the simple principles of surgical practice.

A bettered detail is presented, but no new argument. The issue is simple. It is surgery versus slough; primary union versus slow granulation. With the line of demarcation clearly foreknown, surgeons cut away what is sure to drop away, then ligate, then close in the raw surfaces.

The detail referred to is a handier form of suture-ligature with an outward drag on the skin of the skin cuff of the cord to draw a fold sidewise away from the vessels for the needle to pierce, first on one side, then on the other. Thus the fearsomeness of prodding a vessel, that seems to withhold some men from suturing, is banished.

OUTFIT

Needle, straight or curved, with cutting point; the point tested for sure sharpness.

Stitch, fine silk, or linen, or silkworm, threaded into needle before boiling.

Thumb forceps or mouse tooth thumb forceps.

Needle holder, if curved needle is used; better for all needles, as it saves touching the needle; needle placed in needle holder before boiling.

Boiling the above in towel or in tray or dish. Not removed from towel or tray until used.

Sterile gauze sponges; one or two safe towels; binder.

STEPS

1. At the very moment of the exit of the navel of the child from the vulva, a clean towel covers the cord and encircles the trunk.

2. The cord is clamped long and cut long.

3. Later, when the mother is cared for, child and outfit are laid on the table (Fig. 1). One hand of the nurse holds the baby's legs downward and towels are placed to cover the child. By means of the clamp placed at birth the cord is lifted straight up with the nurse's other hand. Thus the skin cuff is drawn out to its full length. Thumb forceps seize half of the skin cuff, at right angles, at its middle, sliding the skin sidewise, away from the vessels; whereupon the needle pierces and takes up all of this upright fold, near its base, near the belly, and the thread follows. The opposite side is treated in the same fashion, entering near the first entry, coming out near the first exit. We thus have a combination of buried ligature and inrolling skin suture.

4. The loop is held to one side and the cord, still held upward tensely, is cut away at or just beneath the skin edge. All white surface must come away, and all or nearly all the jelly should come away.

5. The stitch is tied, the skin inrolling altogether or nearly so.

6. A dry dressing is applied, whereby the edges roll themselves in completely.

7. One or two days later the stitch is cut and removed.

This inrolling suture ligature I have used for fourteen years or more. It is simple to apply, but less easy to describe. The diagrams (Fig. 2) will make the technique clear. Half of the cord is circled subcutaneously in the fat layer. Then the needle is carried outside to re-enter near the first entry in order to encircle the other half of the cord, making exit close to the point of exit of its first trip. When this ligating stitch is tied, the loop and the tied ends crossing the open surface draw together its two sides. Even if actual apposition of the skin edges does not result, the invariable habit of the navel to retract within an hour or two secures apposition of the edges, and these edges are sealed by a small blood-clot or by dry serum. Primary union occurs except where the amputation has been too high, leaving a certain amount of the shining covering of the cord or of jelly. Therefore, one should see to it that he fearlessly cuts through and even carries away a little of the thin skin edge in order to provide raw edges to unite. A very sharp cutting needle is needed, and sharp scissors, as no skin is tougher than that hereabouts.

The after-care consists in dry dressing with plain gauze or in any other fashion favored by surgeons for wounds where primary union is desired and where the stitch is to be removed within a couple of days. The best suture material is fine silk or linen, either plain or impregnated. Silkworm is a bit clumsy. Catgut usually works well, but does not live up to the best surgical technique, and may produce redness by the second day unless No. 0 is used.

Oozing has not occurred, nor has sepsis. Theoretically the vessels might be supposed to retract inward, away from the grip of this ligature.

[1] Read before the American Gynecological Society, May 11, 1916.

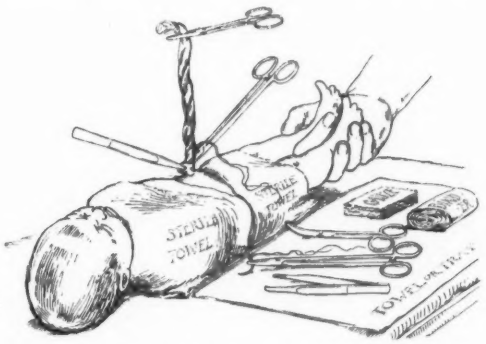

Fig. 1. Child and outfit on table. Baby's legs held downward by nurse.

Practically they are so adherent to the somewhat rigid sides of the opening that they do not slip.

Clips of various forms have been tried. Because of the general fear of the needle, I devised, many years ago, various substitutes in the way of clamps with needle points to bite into skin, some held by a lock, others by a spring. All have been abandoned. Michel clips, particularly in the large size, are effective, but do not give assurance of vessel seizure. In using them the skin cuff is secured, held aloft between thumb and finger, or by a transverse clamp with fairly springy blades until the clips are in place. Those familiar with clips may be more at home with this method. The original publication showed other experiments, such as separate ligature of the vessels, but these were soon abandoned.

The closure of the normal hernial opening — the umbilical — and the prevention of later bowel protrusion would not seem to be favored in any measurable degree by this procedure. The reason is that this suture does not bring into apposition denuded fascial surfaces. The most we do is to close the gap, and this gap is made up of the lumen of the umbilical vein. If suture ligature at the level of the recti muscles or their sheaths causes agglutination of the vein wall and provides for the absence of a clot at this level, then we have favored or hastened closure of the hernial gap. I have not made more than nine tests of placing deep-dipped fascial bites.

Infection is, of course, invited by any lack of good technique, and it is not to be supposed that a midwife will be trusted with this method. But any student who can sew up a scalp wound can put two stitches in a navel. Where the vulva is unclean or the navel of the child has come against fæces expelled with the birth, or in a breech delivery — in other words, where contamination

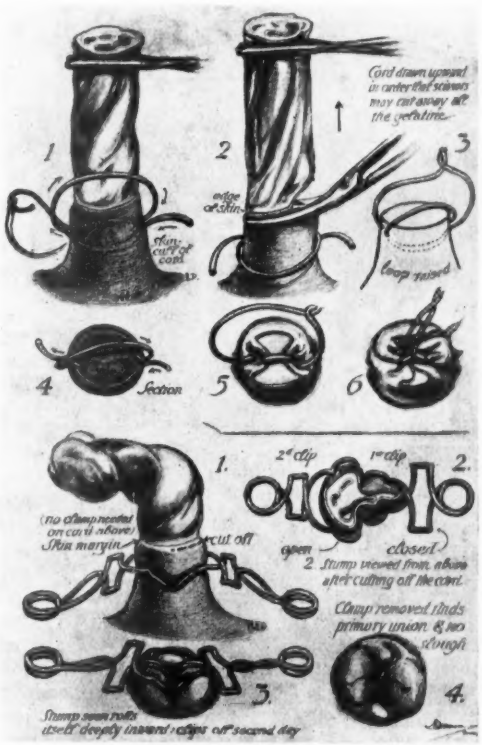

Fig. 2. Amputation of umbilical cord at the skin edge at birth by use of suture ligature or clip.

of the navel has occurred — one is not called upon to invite trouble by stitching. The one infection I have heard of was the result of the work of an interne under one of these conditions. Dr. Fry tells me he had oozing once. As far as I know other men have not had unfavorable results to report, not having tried it. I have only one group of converts. All the nurses who see the after-care, namely, a cord sealed, closed, clean, requiring no dressing, are keen about a process that risks no breaks of their surgical cleanliness from daily dressing of a sloughing wound.

The proposition to suture-ligature was made in 1899.[1] Nothing ever fell flatter. At most it has been dismissed with a footnote of ridicule. But its adoption seems to me inevitable as soon as men midwives are trained to do cleanly minor surgery.

[1] Dickinson, R. L. Is a sloughing process at the child's navel consistent with asepsis in childbed? Am. J. Obst., N.Y., 1899, June (with review of literature to date).
Cullen, T. S. Embryology, Anatomy, and Diseases of the Umbilicus together with Diseases of the Urachus, 1916, pp. 45-46 and 97-100.

PERMANENT NERVE-BLOCK FOR CHRONIC INTRACTABLE PAIN

By FREDERICK G. DYAS, M.D., F.A.C.S., Chicago

GREAT as are the advantages of local anæsthesia, I believe that its greatest field of usefulness has just been opened up. I refer to the permanent nerve-block for the relief of chronic pain.

This method of treatment must be reserved for those patients who have gone beyond the hope of other relief; as in recurrence of malignant tumors after operation. If it were possible, by the injection of those nerve-trunks which supply the painful area, to produce a localized analgesia, the necessity for the use of morphine would be obviated, and the unfortunate patient might be conducted to a peaceful end.

It is well known that morphine and other drugs of its kind do not entirely control the severest pain. I recently lost a case of recurrent carcinoma of the breast with enormous swelling of the arm upon the affected side, in which the pain toward the last could not be controlled entirely by hypodermic injections of one and one-half grains of morphine every two hours. It is in such a case that the proposed method of alcohol injection of the brachial plexus by the method of Kuhlenkampf, would render the entire upper extremity anæsthetic. Of course at the same time there would be a motor paralysis, because the nerve-trunks are made up of both motor and sensory fibers. However, the loss of motor power under such conditions would be neglible.

The same method can be used in carcinoma of the pelvic organs by blocking the sacral plexus. For hopeless conditions of the upper abdomen the paravertebral injection of the intercostal nerves might be employed. This method was suggested to me by the well-known use of solutions of alcohol in from 40 to 60 per cent strength, for injection of the trigeminus nerve in cases of tic douloureux.

Those who have used this method most extensively, say that perfect analgesia is produced whenever the alcoholic solution reaches the nerve-trunk. This analgesia persists from six to eighteen months. If this same analgesia can be produced in those nerve paths which conduct the painful sensation from the diseased area, we shall be able to produce as complete a loss of pain for as long a time as in the case of trigeminus neuralgia.

I therefore predict for this method of local anæsthesia its greatest field of usefulness, and believe that the method of local anæsthesia will continue to find more adherents for its use, both for the production of temporary and lasting local analgesia.

I have used the method successfully in one case of uterine carcinoma by injection of the sacral nerves through their foramina and in one case of sarcoma of the shoulder by Kuhlenkampf's method.

CONCLUSION

Nerve-block as a lasting anæsthesia for chronic pain should find as wide an application as its use for operative procedure.

A SPIRAL WIRE DRAINAGE TUBE FOR SURGICAL DRAINAGE[1]

By FRANK A. GLASGOW, A.B., M.D., F.A.C.S., St. Louis, Missouri

THE experiences of the surgeons in Europe with the fearfully lacerated and infected wounds made by modern projectiles and explosives, have taught them the futility of measures which until a year or so ago were considered nearly perfect.

In the war zone infected wounds are the rule. The gas bacillus is added to the organisms against which we have been accustomed to fight. Antiseptics of an efficient strength have favored sloughing and hindered repair. Bichloride, carbolic acid, and the cresols are falling into disfavor. Milder and less poisonous antiseptics have been sought.

The old Labarraques solution, or this solution with it alkalinity (which was destructive) neutralized with boric acid, is much in favor. The normal saline solution used as a constant bath or drip seems to have given the most satisfaction. Complete drainage is demanded. For some reason rubber tubes have not proved satisfactory. Perhaps it is because the drainage is not perfect as it depends on holes in the tube. Some tubes seem to have a destructive effect on the tissues, perhaps due to sulphur or some other content.

I have thought that a far better drainage could be obtained by a tube made of fine wire wound as is a spiral spring. For many years I have used with very great satisfaction such a drain with a button on the end, as a stem pessary and drain for the uterus. I have accomplished with this results which could be obtained with no other method of drainage.

I first used a number of loops of silkworm gut fastened at one end to a lump of gutta percha. I then devised the following:

All that is needed is a knitting needle and some fine aluminum, silver, copper, or, best of all, enameled copper wire.

One end of the wire is twisted around the end of the knitting needle for a few turns. The wire is then laid along the needle for two and one-half inches and wrapped closely back over the wire toward the fastened end. When this end is reached it is cut off short, close to the spiral. We now have a very flexible spiral, with one end coming through the tube. This end is cut off to a length of three-quarters of an inch and passed through a fair sized pearl button, and then back into the lumen of the tube. This is the complete stem pessary and drain. It may pass around an abrupt angle, like a flexed uterus, and still its lumen remains open. It cannot cause trouble by pressing on the wall of the uterus by its end, as a stiff stem pessary does.

This spiral can be made very small for use in undilated non-parturient uteri, or it can be made as large as a pencil for post-partum cases. It has given me invaluable aid in the treatment of cases demanding drainage. I have used it in some cases of abscesses very successfully.

The uterine drain stays in well unless the cervical canal points in the axis of the vagina. In this case a Hodge pessary must be used to hold the cervix backward.

It has occurred to me that this drain might give better results in wounds, than the rubber tube has done, on account of the more perfect drainage into the tube and the smaller diameter for a given caliber. If made of fine silver or copper wire it seems to be as flexible as rubber tubing. The bare metal wire can be disinfected readily by pouring alcohol or whisky on it and setting it afire, or even holding it in a flame. The enameled wire can be boiled.

It can be fastened in a wound by a small wire passing through its caliber to the middle or end then between the winds into the tissue, then back along the outside of the tube. Twist the ends, and it, together with the tube, will remain until the stay wire is cut and withdrawn.

If this spiral drain is large enough, a very small soft catheter may be passed the whole length, washing from the very bottom of the wound. Continuous drop irrigation, if thought necessary, may be used in this way.

The pliability of tubes made of Nos. 26 to 28 B. & S. enameled copper, or silver wire will surprise any one who has not examined them. For the came caliber these wire drains are much smaller than rubber, as the wire wall is very thin. Perhaps the metal of which they are made may have some specific effect on certain organisms. We know that the minutest trace of copper has a destructive effect on the typhoid bacillus, also on algæ. Perhaps it may have on the gas bacillus.

Silver is thought by some to have an antiseptic effect. Salts of aluminum we know have, and aluminum is slowly dissolved by any alkaline fluid such as the blood.

I have recently obtained some enameled wire

[1] Received for publication November 4, 1916. Read before the St. Louis Medical Society, March 8, 1916.

such as is used for magnet coils. The best sizes to use are Nos. 26 and 28. The smaller sizes make more flexible drains than does rubber. They have a larger lumen for the external diameter. This wire seems to me to be ideal for the purpose. It costs at present about as much per pound as silver wire does per ounce. The copper wire is covered with a dense layer of cellulose, such as artificial silk is made of. It is perfectly smooth, non-hygroscopic and not acted on by weak acids or alkalies. Neither turpentine nor gasoline affect it. It may be subjected to a temperature fo 600 degrees Fahrenheit without detriment. It may be boiled for any reasonable time without injury, as instruments are. I believe it is as innocuous to the tissues as silkworm gut.

Iron wire may be used. I have used the wire from an old broom, wrapped on a lead pencil. The drains can be made by any one anywhere. They can be wrapped on tool steel rods or on knitting needles. A lathe will do the work rapidly. A bandage roller or an ordinary brace fixed on a box can be used very well.

If a number of steel rods of various sizes have about 1½ inch on one end made of a uniform size, they may be inserted in a hole in a bandage roller and utilized to wrap the wire. Convalescent patients could do the work.

These tubes may be inserted, say through a bullet wound in the thigh, by placing a copper rod in the spiral to project just beyond the end. This rod may now be bent to any desired curve and inserted entirely through the wound or only to the bottom. The rod is withdrawn, leaving the tube. A copper or aluminum wire is better than steel, as it may be bent.

If the tip of the rod could be placed just into a cavity, the drain could be pushed off of the rod deeper into the cavity.

This drain might be introduced into a tortuous channel where no rubber or other drain could possibly be placed. Possibly in this way some cavities about the head, as the frontal sinuses or the Eustachian tube may be drained.

The wire from the buried end of the spiral is brought out through the tube, the tube may be unwound from its buried end and so shortened from the bottom of the cavity. If 2 inches of wire corresponds to ¼ inch of length, then pulling out 2 inches will raise the end of the tube ¼ inch from the bottom of the cavity. This can be done daily until the whole tube is unwound. The tube does not rub the tissues as it would if withdrawn.

The upper end may be fastened to the skin, or a safety pin used.

These tubes may be made in sizes from $\frac{9}{32}$-inch down to the size of a small knitting needle.

It is necessary that one end of the wire of a drain should be passed through the drain. A drain may be strengthened at its outer end by wrapping back over the steel rod for about one fourth inch, then making a small loop by twisting a portion of the wire. Now lay this loop along the reinforced part and take a few turns of wire over it. The drain is now fastened to the skin by means of a safety pin through this loop and the skin, or by a stitch.

I believe in practice it would be well to have a strip of sheet metal bent into the shape of a tube, but not completely closed on the side to contain the tubes, as they are easily deformed. The container with the tube could be placed with the instruments and boiled, and the spiral removed when needed. These containers of thin copper or aluminum would be very inexpensive.

As my work is almost exclusively gynecologic and hence confined to the pelvis and abdomen, I have little opportunity to try these drains, but have used them in a few cases of pelvic abscesses with success. On this account I hope that I may be excused for making almost a purely theoretical offering to the profession. I have never seen in print or heard of any one using such drains, so it may be possible that my suggestion is original.

Since writing the above, I have used the enameled wire drain a number of times and find it perfectly innocuous to the tissues. N. B. Carson of this city, who is well known to the surgical profession, has used the drain extensively and finds it entirely satisfactory. It does not absorb fluids and gases nor injure tissues as rubber tube drains do.

There are some samples of enameled wire on the market which do not stand boiling. Perhaps the true cellulose covered wire which the books on electrical supplies describe is not obtainable. If the samples obtainable here are not cellulose covered they seem to be just as serviceable if not subjected to an oil solvent or boiled too long.

MEDICINAL TREATMENT OF AMŒBIC ABSCESS OF THE LIVER

By WILLIAM ALLAN, M.D., Charlotte, North Carolina

UP to about a decade ago, tropical or amœbic abscess of the liver was one of the most serious maladies of tropical and warm temperate countries, showing a mortality in untreated cases of 75 per cent (1). Under the purely surgical treatment of incision, evacuation and drainage, there followed an average case mortality of about 60 per cent (2). This frightful mortality following surgical interference is not surprising when the pathology of the lesion is considered. There is, of course, no abscess wall or inflammatory barrier, but an irregular advance of the invading organisms leaving coagulation-necrosis and thrombosis of the blood-vessels in their wake. While evacuation of the contents will put an end to absorption and fever, it may have not the slightest effect on the progress of the necrosis, and open drainage will often superimpose a pyogenic infection. Thurston (3) in 1914 reported 100 cases of liver abscess treated in various ways and concluded that incision with drainage had become an obsolete procedure in the proper handling of these cases.

Aspiration of the abscess without drainage came as the next step in advance and brought a considerable reduction in mortality, probably chiefly by preventing subsequent pyogenic infection. As early as 1892, E. Lawrie (4) cured 15 out of 18 cases of liver abscess by repeated aspiration without drainage, and Cantlie (5), using Manson's method of closed continuous siphon drainage, had 82 recoveries in 100 cases. The advantage of aspiration over open drainage is even more strikingly shown by Chaterji's (6) figures in his series of 48 cases; in 15 cases opened and drained the mortality was 60 per cent, while in 33 cases treated by aspiration the mortality was only 6 per cent.

The injection of 2 per cent quinine solution into the abscess cavity after aspiration, as recommended by Rogers, has proved to be of doubtful value.

About ten years ago, due mainly to the efforts of Rogers in India, the use of ipecacuanha became a routine measure in all cases of amœbic abscess of the liver, regardless of what method of emptying the cavity was to be employed. This proved to be the greatest advance yet made in the treatment of this malady, for within two years after its general adoption by the British Army in India, the admission rate for liver abscess fell from 2.4 to 1.4 per 1,000 troops and the death rate from 1.3 to 0.48 per 1000 troops and the case mortality from 54 to 34.3 per cent (7). In Thurston's series (3) of cases the mortality fell from 40 per cent in those treated by surgery alone to 28.6 per cent in those cases in which ipecac was combined with surgery. The verdict in favor of this drug as a cure for amœbic hepatitis, as a preventive of abscess formation, and as a *sine qua non* in any treatment of existing abscess has become unanimous (8).

The substitution of emetine for crude ipecac has marked as great an advance in the treatment of liver abscess as in the treatment of amœbic dysentery, and its use is now a matter of routine, whatever other measures are adopted. The literature is full of reports of chronic abscess, discharging through the lung, that were speedily dried up by its use, and the fact that emetine shortens remarkably the drainage time after open operation is undisputed.

This success with emetine has naturally given rise to the hope of abolishing surgery entirely in the treatment of amœbic liver abscess. But, strange as it may seem, in the vast majority of cases reported since emetine was introduced, surgical measures have preceded or have been simultaneous with the use of emetine, very little effort apparently having been made to determine what medicinal treatment alone will accomplish. A few scattered instances of both success and failure with the drug alone are reported, but only Dopter (9) seems to have attacked this specific problem. He is quoted as being "convinced that evacuation of these abscesses is absolutely necessary. The emetine converts the abscess into a dead one, that is to say it kills the amœba and prevents the further production of pus, but is powerless to effect the absorption of the pus already formed."

As my experience in three recent cases has been directly the reverse of that reported by Dopter, these cases should be of interest at the present time.

Case 1. White, male, age 30, seen January 11, 1915, with Dr. E. C. Boyette. The present illness had started five weeks previously with fever and pain in the region of the gall-bladder. The patient had had fever daily in the meantime and for the past week had been somewhat jaundiced. Pulse 80, temperature 99, leucocyte count 22,000 with 85 per cent polynuclears. Physical examination revealed liver dullness up to the fourth rib in front

and up to the angle of the scapula behind: the lower border of the liver was two inches below the costal margin. The loss in weight had been 40 pounds. There had been no loose bowels with the present illness but in August, 1914, there had been painful bloody dysentery for two weeks. The urine showed a trace of bile and the fæces contained a streak of bloody mucus with monads and pathogenic entamœbas. Patient admitted to Presbyterian Hospital January 14, and given emetine gr. 1. Given emetine grs. 2 on January 15 and 16; grs. 1.5 on January 17 and 18; gr. ½ on January 19 and 20; and gr. 1 on January 21 and 22. The temperature subsided by the fifth day and on January 24 the man was discharged. His jaundice had cleared up but the boundaries of his liver were unchanged. He reported May 19, 1915, with a gain of 25 pounds in flesh, and liver boundaries normal. During the past two years there have been a number of recurrences of the dysentery, but no recurrence of the liver abscess.

CASE 2. White, male, age 29, seen with Dr. C. G. McManaway, May 22, 1916. The patient gave a history of attacks of chills and fever for the past fifteen years, coming on about every six months, and lasting from a week to a month. After a month of chills and fever in 1913 he had a pus gall-bladder with stones removed and was free from attacks for a whole year afterward. Had chills and fever for four weeks during January, 1916, and the present attack had already lasted ten days. His chills came on at any time during the day or night and varied from slight shivering to violent shaking with high fever and severe vomiting. Has had no pain but is losing about two meals a day. During the present attack he has been having from 4 to 6 stools a day with two during the night. This is the nearest he has ever come to dysentery, as heretofore he has always been constipated during his attacks. Has never had loose bowels between attacks. Physical examination revealed nothing except enlargement of the right lobe of the liver downward for three fingers: upper border of liver normal. The loss of weight during the present illness has been 18 pounds. When first seen at noon, May 22, pulse 88, temperature 99, white blood count 30,000, with 80 per cent polynuclears, no plasmodia. Urine normal. Fæces contained pathogenic entamœbas. May 19 a chill at 4 p. m. with fever 104°; May 20 a chill at noon with fever 104.6°; May 21 no chills; May 22 a severe chill at 4 a. m., and a second at 4:30 p. m. That night he was given emetine 1 gr. and this was repeated for ten days. There were no more chills, after the first dose of emetine. January 6, 1917. No recurrence, liver normal.

CASE 3. White male, age 37, seen with Dr. J. L. Ranson September 1, 1916. The patient had been having chills, fever, sweats, cough. and diarrhœa for three weeks. Temperature 101°, pulse 80, white blood count 14,000 with 88 per cent polynuclears and no plasmodia. There had been some pain over the upper abdomen and the epigastrium was bulging, symmetrical, smooth, dull on percussion, tender and looked as though a large grapefruit had been slipped under the end of the sternum and the costal arch. Physical examination otherwise negative. Urine normal. Fæces showed pathogenic entamœbas. Emetine gr. 1 was given daily for eight days and by the third day the temperature had subsided and the pain disappeared. The patient reported October 19 with a perfectly normal left lobe of the liver so far as percussion and palpation could determine, and with a gain of 30 pounds in weight.

Spittel's (10) observation is interesting in this connection. He reports a case of liver abscess which was aspirated, then opened and drained, and the patient given emetine ½ gr. for five days. The drainage tubes were accidentally removed and the patient died on the nineteenth day from general peritonitis. The autopsy showed that "several separate foci of pus had been rendered inert and crystallized into solid, buff-colored islets which disclosed microscopically the very beginnings of fibrosis" and also disclosed a rapidly advancing fibrosis three-fourths of an inch thick in the wall of the cavity. The size of the cavity had shrunk from one and a half pints to four ounces in the 19 days since operation.

The urgent need of an adequate medical treatment for those cases in which multiple abscesses are present is too obvious to require elaboration.

We shall probably always encounter some abscesses too large to be absorbed and in these cases aspiration is indicated, but only after the amœbic process has been stopped with emetine. In view of Spittel's observation and the cases cited above it is evident that the small and moderately large abscesses can be cured by emetine alone, in a certain percentage of cases. Only considerable future observation will show how large this percentage will prove to be.

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TWO FRACTURE DEVICES

By J. E. CANNADAY, M.D., F.A.C.S., and H. D. HATFIELD, M.D., F.A.C.S., Charleston, West Virginia

IN our fracture service we have found the two types of fracture apparatus described below to be simple, economical, and efficient, and we believe them to be desirable additions to the fracture armamentarium.

The first (Figs. 1, 2 and 4) is an extension apparatus intended for use in conjunction with a plaster cast. This device consists primarily of a light bronze aeroplane turnbuckle to each end of which an anchor has been solidly fitted by a blacksmith or machinist. These anchors are roughly in the shape of a cross, the long end of which a short distance above the cross bar is bent outward at right angles so as to engage the eye which protrudes at either end of the turnbuckle. It is solidly riveted into this eye so there will be no rocking or lateral motion. These turnbuckles have a spread of two inches or more. In the treatment of the usual fracture of the arm or leg, three of the above-described units are used. These are spaced so that one is on either side and one anteriorily.

To apply this apparatus, the fractured limb is first carefully protected over all bony prominences with cotton batting or absorbent cotton and flannel bandages. A light plaster cast is applied and allowed to partially harden. The extension apparatus is applied over this. The anchor ends are secured by a few additional turns of plaster bandage. As soon as this has hardened sufficiently for the anchors to be held securely in place the cast encircling the limb is sawed in two with a keyhole saw at a point about the center of the turnbuckle. The extension can be made immediately up to the point of tolerance of the patient. These turnbuckles are perforated near the center for the insertion of the key used in extending or shortening the turnbuckle. If the surgeon desires to avoid needless meddling with the apparatus, a small wire can be passed through the perforation at the center of each extension piece and the ends secured by a small lead seal such as is used in sealing cars.

In securing extension below the knee, good resistance against the pressure of the cast can be obtained by having the knee well fixed before the application of the cast, which extends well up on the thigh. If applied to the forearm the pressure is made against the sides of the hand at one end and the flexed upper arm at the other. When the humerus is broken, extension can be made against the side of the chest with the arm extended at almost a right angle from the shoulder and against the flexed forearm. If the fracture is in the thigh, the pressure is made against the pelvis above and is secured by the flexed leg below.

This means of extension is very effective in comminuted fractures, if applied early, before strong muscular contraction has taken place. Wounds of the soft parts can be readily dressed through windows cut in the cast. The separated sawed ends of the cast need not be at the point of fracture. The extension is constant and can be easily regulated.

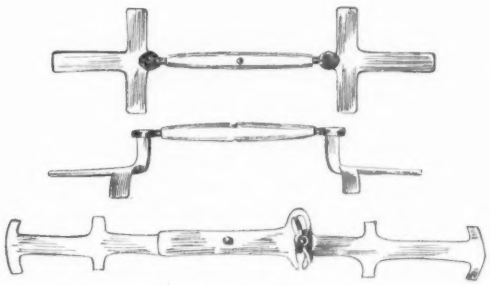

Fig. 1 (above).
Fig. 2.
Fig. 3.

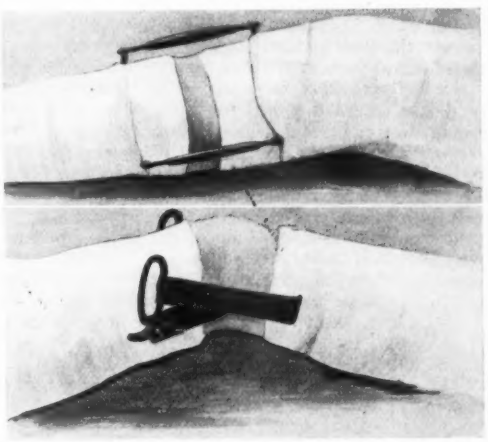

Fig. 4 (above).
Fig. 5.

The second apparatus (Figs. 3 and 5) consists of a special hinge for the knee. Two of these units may be used when it becomes necessary to include the knee in a plaster cast in the treatment of fractures of the femur or tibia. This hinge can be made by any good blacksmith. It has a simple locking device which consists of a short pin which works in a slot. The hinge can be secured at any point by tightening a thumb screw. The anchors of this hinge are four inches or more in length, in order that they may be firmly fixed in the plaster cast. This hinge apparatus is incorporated in the plaster cast in the same manner as the turnbuckle extension device. By the use of this hinge, two pairs of which are used, one on either side of the knee, the surgeon maintains relative immobility and extension and each day can loosen the locking device and give the joint passive motion, thus preventing the undue amount of stiffness often seen in the knee-joint after long absolute immobility in a plaster cast.

CORRESPONDENCE

NOTES FROM THE SURGEON-GENERAL'S OFFICE

To the Editor: Should the country ever be engaged in war, the Medical Department of the Army in calling Reserve officers to the colors, wishes to cause as little hardship and sacrifice to the Reserve medical officers as may be consistent with the needs of the country. With this end in view the Department desires that you bring to the attention of the profession at large the necessity of the city, county, and state medical societies organizing for the purpose of taking care of the practices of the officers of the Reserve who respond to a call for service. In England this plan has proved of great benefit. The idea of the Department is that the profession should organize upon a similar basis.

For example, should Dr. Jones be called to the colors, the local medical society, through its members, would take care of his practice during his absence. Upon relief from active duty his practice would be returned to him intact. Such a plan will cause no unnecessary hardship upon the officer responding to a call for service; while the absence of such plan would penalize the officer who gives his service to the country in a crisis. The Department appeals to the patriotism of the profession, to protect the interest of those of the profession who may be called to duty in war.

For the Surgeon General.

ROBERT E. NOBLE,
Major, Medical Corps, U. S. Army.

ARMY MEDICAL CORPS EXAMINATIONS

The Surgeon General of the Army announces that preliminary examinations for appointment of First Lieutenants in the Army Medical Corps will be held at convenient points the first Monday in each month. Full information concerning these examinations can be procured upon application to the "Surgeon General, U. S. Army, Washington, D. C."

The essential requirements to secure an invitation are that the applicant shall be a citizen of the United States, shall be between 22 and 32 years of age at the time of commission at the close of the Army Medical School, a graduate of a medical school legally authorized to confer the degree of Doctor of Medicine, shall be of good moral character and habits, and shall have had at least one year's hospital training as interne after graduation.

Graduate physicians who are serving their internеship and who meet the other requirements can be examined for appointment with the understanding that they will complete the required postgraduate hospital interneship before coming to the Army Medical School.

Those who qualify at their preliminary examination and complete their hospital interneship by July first will be ordered to the Army Medical School for the special session of the school commencing July 9. The regular session of the school will open on October 1.

In order to perfect all arrangements for the examination, applications should be completed at the earliest practicable date.

There are at present 230 vacancies in the Army Medical Corps.

After July 1, there will be 222 additional vacancies.

TRANSACTIONS OF SOCIETIES

CHICAGO GYNECOLOGICAL SOCIETY

Regular Meeting held Friday Evening, November 17, 1916, with the President, Dr. Channing W. Barrett, in the Chair

EARLY ECTOPIC PREGNANCY; TUBULAR VARIETY

Dr. W. A. Newman Dorland reported a case and presented a specimen of very early ectopic pregnancy of the tubal variety with the following history: The woman menstruated October 1, for three days. The November menses were missed. On November 10 she suffered an attack of colic on the right side and fainted. Dr. Norman Kerr, who was called in, pronounced it either appendicitis or tubal pregnancy. The patient experienced a second attack of pain in the afternoon of that day and on Sunday morning, two days later, had a third attack. A diagnosis of ectopic pregnancy was made and immediate operation advised. I saw the patient on the afternoon of November 12, and agreed in the diagnosis with Dr. Kerr. I operated on the case Tuesday morning, November 14. At first I thought it was merely an intra-uterine pregnancy, as there was no sign of pathology and only a moderate uterine enlargement. A foreign body was felt in the tube, however, which was removed. There were no adhesions around the tube, nor, what is still more interesting, was there any hæmorrhage into the peritoneal cavity.

On carefully incising the upper margin of the resected tube the tiny gestation sac was revealed. This is probably as early a case of tubal gestation as that recently reported by Bandler, of New York, which, he claimed, was probably not older than ten days.

DISCUSSION

Dr. Maxmillian Herzog: This is probably a very young ectopic gestation (referring to the gestation-sac), but to judge of its age, sectioning would be necessary. It may be young or not. The age can be accurately determined by an examination of the embryo, if that has been preserved. If not preserved, the age can be approximately determined by the villi, although sometimes their appearances are deceptive. I have had several of that kind, one almost as small as this, but in no case could I find the embryo.

Dr. Dorland: In order to show this interesting specimen to the society the case was presented before sectioning was done. That will, however, be done at an early date.

DIFFICULT DELIVERY OF SHOULDERS

Dr. Joseph B. De Lee presented the report of a case as follows:

A woman with a contracted pelvis who had had difficult labors before, and who always presented great difficulty in the delivery of the shoulders, went into labor a few days ago. The child was larger than her other children, and the shoulders remained above the inlet and could not be brought down. I attempted to break the baby's clavicle but could not do so. I tried to pull down the arm, with brute force, hoping to break the humerus, but failed. The baby began to gasp, but it could not get any air into the lungs. The idea occurred to me to insufflate the baby's chest still held in the uterus, so I passed a catheter into its trachea, and aspirated a little mucus from the windpipe and performed artificial respiration by mouth-to-mouth insufflation, the child's chest being above the superior strait. Only a small amount of air could get in, but it was sufficient to keep the child alive. I was very deliberate in the subsequent process of delivery, which required eight or ten minutes, during which time the catheter was in the baby's lungs and the air could be heard going in and coming out.

I recommend this method for more general application, and I hope it will save some babies who might otherwise be lost. With more experience I think one could catheterize the baby's lungs after breech delivery with arrested head.

Finding that I had plenty of time, I succeeded in delivering the baby by gradually molding, by combined external pressure and internal traction, the shoulders to the passage, bringing down one arm with great deliberation, then the other arm, thus delivering a child that was gasping through a tube, but uninjured, with no Erb's paralysis and no fracture. The weight of the baby was eight pounds and eight ounces. The pelvis was generally contracted, with a conjugata vera of 9 cm.

PORRO OPERATION FOR FIBROID COMPLICATING PREGNANCY

Dr. A. J. Schoenberg reported a case of Porro operation for fibroid complicating pregnancy, and exhibited a specimen (Fig. 1.)

The patient from whom this specimen was re-

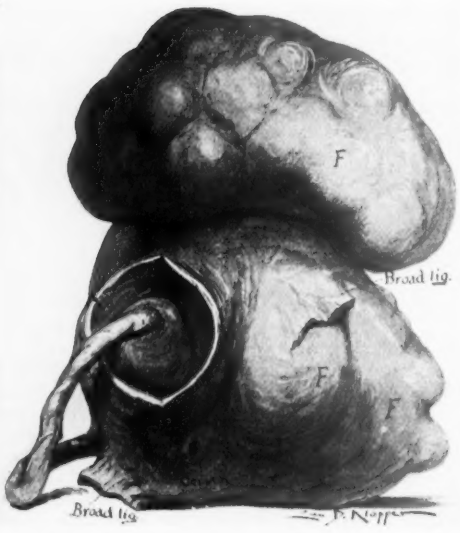

Fig. 1. Dr. Schoenberg's case of fibroid complicating pregnancy.

moved was a Swedish woman 37 years of age. Family history negative; mother still living and well. Personal history negative with the exception that she had always been constipated and was never very strong. She began to menstruate at 13, always regular, 28-day type, moderate in amount, and lasting 3 to 4 days. This was the first pregnancy; she had been married one year. For the past two years she has had more or less pain in the lower abdomen.

Early in October, 1915, she began to have morning sickness and suspected pregnancy. She menstruated at her regular period in September and October, but in November the menses did not appear. Pains gradually increased and were so severe that at times she could hardly walk.

January 1, 1916, she consulted a physician, who informed her that she had a water-tumor and advised immediate operation for its removal. She, however, decided not to be operated on. Soon thereafter she thought she felt quickening. In February she consulted a midwife, who, after looking her over, advised that she go to a physician.

Early in May she consulted another physician, who diagnosed a possible twin pregnancy and accepted the case on condition that she go to a hospital. The probable date of confinement was computed to be about June 30. On June 18 she was thought to be in labor and was sent to the Evangelical Deaconess Hospital. The pains subsided the following day and she returned home; but the pains soon recurred and continued until Saturday, June 24, when she again was taken to the hospital. She had been having very severe pains during her stay at home from June 19 to 24; at times she rolled and writhed in pain, lying on the floor.

The writer was called to see the case Saturday, June 24. Examination at that time revealed a rather poorly nourished woman showing evidences of exhaustion; no marked increase in pulse-rate; heart and lungs negative. The abdomen was irregularly and asymmetrically enlarged. A large tumor was felt in the upper abdomen and another in the side, feeling not unlike a fœtal head. The vaginal examination showed the vulva and vagina to be normal except for the congestion due to pregnancy. External os not dilated, cervix only partly effaced, vertex presentation. Fœtal heart-sounds could be elicited but were rapid and weak.

Diagnosis: single pregnancy with multiple fibromyomata.

Because of long labor and no engagement, indicating lack of adaptability of the child's head to the pelvic outlet, delivery by the normal route was impracticable. Immediate cæsarean section was therefore decided upon. This offered immediate relief for the mother, the best possible chance for the child, and an opportunity to deal with the fibroids as the conditions demanded. The abdomen was quickly opened and the large tumors could be seen. The uterus was rotated and studied. An incision was made with its middle slightly below the navel, a foot sought, and a rather poorly nourished child delivered and resuscitated after some effort. Hysterectomy was then decided upon for the reason that it was necessary to remove the tumors, myomectomy being impracticable; hæmorrhage was possible, and infection feared. The specimen shows that myomectomy would have been a very serious undertaking. The uterus was at once raised out of the abdomen, clamps applied to the broad ligaments and the uterus with its tumors removed; the ovaries were found to be healthy and were left. A gauze-drain was passed through the cervix into the vagina, the round and broad ligaments sutured to each side of the cervix and the stumps covered over with the anterior and posterior flaps of peritoneum. The child weighed 5 pounds and 12 ounces. The mother convalesced without untoward symptoms, both going home on the twentieth day after operation. Four and one-half months after birth both mother and child were well.

The specimen shows multiple fibroid nodules, varying in size, the largest of which was about the size of a man's head. The measurement from above downward was 26 centimeters; anteroposteriorly 15 centimeters; side to side 18 centimeters; weight 5,000 grams, or 11 pounds. The gross specimen on section shows that the largest intramural fibroid has undergone myxomatous degeneration.

The result obtained in this case strongly emphasizes the fact that fibroid tumors of the uterus associated with pregnancy should not be interfered with during pregnancy except as symptoms force interference. It further emphasizes the desirability

of giving a woman with fibroids an opportunity to become pregnant before a radical operation is performed unless the symptoms are urgent.

DISCUSSION

DR. DOEDERLEIN: I am reminded of a case of a tumor of about a half-term pregnancy. The tumor was a so-called adenoma of Hartzell and the pregnancy occurred inside of the tumor as determined by microscopical section. I think now that we have a fourth type of ectopic pregnancy in addition to the present three recognized types; namely, the primary tubal, the primary ovarian, and the primary abdominal.

DR. EUGENE CARY: I would like to report the case of a woman whom I saw when four months pregnant. At that time a diagnosis of uterine fibroid was made. One fibroid was about as large as the fist, and lay in the right uterine segment. As the pregnancy progressed the fibroids could be grasped through the abdominal wall with the fingers. The diagnosis of tumor in the uterine wall was concurred in by four men. As the pregnancy progressed to term these fibroid masses became softer and cystic. The woman was delivered spontaneously, with only slight subsequent hæmorrhage. On palpating the relaxed abdomen after delivery no fibroids were palpable.

THE PATHOLOGY OF LATENT SYPHILIS

DR. A. S. WARTHIN, University of Michigan, presented (by invitation) a paper on "The Pathology of Latent Syphilis."

CHICAGO SURGICAL SOCIETY

REGULAR MEETING HELD DECEMBER 8, 1916, WITH THE PRESIDENT, DR. WILLIAM M. HARSHA, IN THE CHAIR

ARTHROPLASTY ON THE ELBOW-JOINT

DR. SAMUEL C. PLUMMER: I wish to present a case upon which arthroplasty of the elbow-joint was done. Before operation the arm was flexed 15 or 20 degrees, and there was no motion whatever in the joint. The patient fell and suffered compound fractures of the femur and also of the humerus near the elbow-joint. Infections developed in both of these fractures. Union did not occur in the femur. The patient had a bad luetic history and poor nutrition. Even though several operations were done there was failure to secure union of the femur, and finally the thigh was amputated at the upper third. Three years after injury he came for operation on the elbow. The position of the arm rendered it about as useless as an arm could be. He could not get his hand into the pocket of his trousers, and although a bad operative risk, I took a chance on an arthroplasty. I found there was absolutely no sign of any joint between the humerus and radius and ulna. It seemed to be a solid bone. There was no joint surface left anywhere, no sign of a joint. I took away a liberal portion of the bone and turned in pedicle flaps of fat and fascia from the neighborhood, and as these were not sufficient, I took a free flap to cover up what could not be covered by the pedicled flaps. Unfortunately he developed an infection, the wound suppurated, a sinus remained, and in the course of time I found I had necrosis of the humerus. So another operation was done and quite a portion of the end of the humerus, at least three-quarters of an inch was taken out. With the infection and necrosis I was afraid the operation was going to be a failure and we would get ankylosis of the bone again. But at the time of the removal of the necrosed humerus I found there was a fibrous layer covering the ends of the bones of the forearm, and I felt sure from that there would not be union again of bones. On account of so much more bone being gone than I intended to take out in the first place, I did not know what function he would get.

He had another untoward circumstance in connection with this. Although I have had some experience with paralysis of nerves from the Esmarch, I thought I had taken every necessary precaution in this case. Before the Esmarch was put around the arm, I folded a towel around the arm, and thought the nerves were safe. After the operation I found total paralysis of the nerves below the Esmarch. Every nerve was paralyzed. In the case of the ulnar nerve, I dissected that out first and kept it out of the way. I know I did not injure it in the operation. It was not long before he began to get some return of nerve function, and now he has made practically a recovery. The only thing he complains of is a little anæsthesia of the little finger and next finger where the ulnar nerve is distributed. Of course, the muscles of the arm were very much atrophied from three years of non-use, but he has been developing them. He can now put his arm away around his shoulder and up behind his head and back of his neck. He can overextend it a little. The functional result is very good and very satisfactory.

You will perhaps remember that at one of the clinical meetings held in St. Luke's Hospital about a year ago I showed another case of arthroplasty. That was a case of a boy of ten who had a fracture of the lower end of the humerus. There was anky-

losis, and I operated on him when he was sixteen. He has grown up to be man size since he had this ankylosis, and his muscles were very much undeveloped as well as inactive from non-use. Although he had good motion his facility for moving the joint was not very good. He studied wireless telegraphy and I received a postal card from him recently from the West Indies, saying he was getting stronger every day and was able to fill the position of wireless telegrapher, which he could not have done with the elbow ankylosed in the same position this one was. In that case there was joint surface between the radius and ulna, and between the upper end of the radius and articular portion of the humerus, which articulates with the radius, but the ulna and humerus were as one solid bone.

SYMPOSIUM ON MILITARY SURGERY

DR. JACOB FRANK, Lt.-Colonel, Surgeon-General of the State of Illinois, gave a talk on his "Experiences of a Chief Surgeon in a Mobilization Camp."

DR. H. M. RICHTER, Chief Surgeon Base Hospital at Naumburg on the Saale, read a paper entitled "General Considerations of Service with the Central Powers."

DR. G. G. DAVIS, Lt.-Colonel R. A. M. C., followed with a paper entitled "Surgical Impressions of Service with the British Expeditionary Forces in France."

DR. KELLOGG SPEED, Lt.-Colonel, R. A. M. C., read a paper entitled "Observations of a Senior Surgeon Commanding the Surgical Division of a British Base Hospital in France." (See p. 454.)

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A REFERENCE HANDBOOK OF THE MEDICAL SCIENCES. 3d ed. completely revised and rewritten. Edited by Thomas Lathrop Stedman, A.M., M.D. Eight volumes. Vol. VII: Pac-Sto. New York: William Wood & Co., 1917.

THE BREAST: ITS ANOMALIES, ITS DISEASES, AND THEIR TREATMENT. By John B. Deaver, M.D., LL.D., Sc.D., and Joseph McFarland, M.D., Sc.D., assisted by J. Leon Herman, B.S., M.D. Philadelphia: P. Blakiston's Son & Co., 1917.

THE NEWER METHODS OF BLOOD AND URINE CHEMISTRY By R. B. H. Gradwohl, M.D., and A. J. Blaivas. St. Louis: C. V. Mosby Company, 1917.

A MANUAL OF THERAPEUTIC EXERCISE AND MASSAGE, DESIGNED FOR THE USE OF PHYSICIANS, STUDENTS AND MASSEURS. By C. Hermann Bucholz, M.D. Philadelphia and New York: Lea & Febiger, 1917.

PREVENTIVE MEDICINE AND HYGIENE. 2d ed., thoroughly revised. By Milton J. Rosenau. New York and London: D. Appleton & Company, 1916.

THE DISEASE OF INFANCY AND CHILDHOOD; FOR THE USE OF STUDENTS AND PRACTITIONERS OF MEDICINE. 7th ed., fully revised. By L. Emmett Holt, M.D., Sc.D., LL.D., and John Howland, A.M., M.D. New York and London: D. Appleton & Co., 1916.

MY BIRTH. By Armenhouie T. Lamson. New York: The Macmillan Company, 1916.

BETTER BABIES. By Samuel A. Visanska, Ph. G., M.D. Atlanta Ga.: Foote & Davies Company, 1917.

AN INQUIRY INTO THE PRINCIPLES OF TREATMENT OF BROKEN LIMBS, a PHILOSOPHICO-SURGICAL ESSAY, WITH SURGICAL NOTES. By William F. Fluhrer, M.D. New York: The Rebman Company, 1917.

THE DIAGNOSIS AND TREATMENT OF ABNORMALITIES OF MYOCARDIAL FUNCTION, WITH SPECIAL REFERENCE TO THE USE OF GRAPHIC METHODS. By T. Stewart Hart, A.M., M.D. New York: The Rebman Company, 1917.

CLINICAL GYNECOLOGY. By James C. Wood. A.M., M.D., F.A.C.S. Philadelphia: Boericke & Tafel, 1917.